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PEACE RIVER OILS #1 STUDY

ENVIRONMENTAL ASSESSMENT

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EXECUTIVE SUMMARY

The Environmental Assessment Division of Alberta Environment coordinated an investigation of the impacts which have occurred as a result of continuous water and gas discharges from the abandoned Peace River Oils #1 Well (LSD 4-31-85-20-W5M).

The Peace River Oils #1 Well, the old domestic well on the Nixon property, and the Peace River in the vicinity of the oil well were sampled on several occasions in 1988 and 1989 in order to assess a) the quality of the water flowing from the oil well, b) the quality of Nixon's old domestic well water compared to that of water from the oil well, and c) the effects of the oil well water discharge on the Peace River.

Gaseous hydrogen sulphide emissions in the vicinity of the well were monitored by the ERCB. The land surface adjoining the well was surveyed to assess a) the effects of the well on nearby soils and vegetation, and b) the origin of the alleged "sinkholes".

Chemical analyses carried out on the water samples included routine inorganic chemistry, volatile and semi-volatile priority pollutants, and hydrocarbons. Hydrocarbons were quantified, fingerprinted, and compared among samples. Microtox tests were conducted to assess the toxicity of the water samples. Benthic invertebrate community structure was used to assess whether the oil well discharge affects the aquatic biota in the Peace River. Electromagnetic surveys and soil analyses were carried out to assess soil and subsoil conditions.

Discharged Water

The water which flows out of the Peace River Oils #1 Well contained high concentrations of sodium, chloride, and total dissolved solids (TDS). These concentrations were similar to those of seawater. The well water also had moderate to high concentrations of barium, boron, lithium, strontium, ammonia, hydrogen sulphide, and hydrocarbons. Hydrocarbons and related compounds included weathered crude oil, chloroform, benzene, phenol, other phenolic compounds, and polycyclic aromatic hydrocarbons. The concentrations of several of these organic and inorganic constituents exceeded CCREM (1987) guidelines for irrigation of agricultural land and for the protection of aquatic life. Microtox tests indicated that the Peace River Oils #1 Well water was extremely toxic.

Discharged Gas

Within a 60 m radius of the well, hourly average hydrogen sulphide concentrations ranged from 0.023 to 0.223 ppm and were well in excess of air quality guidelines (Clean Air Act - Maximum Levels - Regulation) which specify maximum hourly average concentrations of 0.01 ppm. Some peak concentrations were beyond the scale of the analyzer in use (i.e. > 0.50 ppm). Hourly average hydrogen sulphide concentrations at a location 300 m east of the well were 0.004 ppm with peak concentrations of 0.005 ppm, and met air quality guidelines.

Domestic Well Water Quality

Sampling of the Nixon's domestic well water was made difficult by the presence of debris in the casing. Although the well is reported to

be 20 m deep, samples could only be collected at a depth of 4 to 7 m. The chemical analyses of the samples reflect the quality of the water in the well, but not necessarily that of the geological formation in which the well is completed. To get a more representative sample, the well would have to be cleaned out and purged to remove stagnant water.

Results of routine water analyses indicate that the well water is of the sodium bicarbonate type, which is often associated with bedrock aquifers. Water well records of the area reveal similar water from wells completed in the river valley both upstream (SW2-85-21-W5) and downstream (SW16-86-20-W5) of the Nixon farm. Water from wells to the southeast, outside of the river valley, is of the calcium magnesium sulphate type, commonly associated with drift aquifers. The chloride level in Nixon's old domestic well is, with 156 mg/L (drinking water guideline 250 mg/L), the highest of the 11 wells surveyed. Next highest, with 65 mg/L, is a well 5 km downstream, also in the valley. Phenols were also identified in the well water.

The analyses of hydrocarbons revealed the presence of heavy hydrocarbons which matched those from the Peace River Oils #1 Well. The Microtox test indicated that the water collected in the old domestic well was extremely toxic.

The high chloride levels, the presence of phenols, the similarity between hydrocarbons found in the domestic and in the oil well and the Microtox test results suggest that the domestic well at Nixon's farm was contaminated.

Peace River Water Quality

The dilution of the Peace River Oils #1 Well effluent in the Peace River was so great (1:10,000 at low flows) that no effects other than a slight increase in chloride concentration could be detected in the water quality of the Peace River at a monitoring site located approximately 30 km downstream of the well. Other factors such as the effect of tributaries and the possible inflow from natural gas wells in the area complicated the assessment.

Closer to the well, conductivity was used to trace the effluent in the Peace River. The well effluent appeared to sink to the bottom upon its entry in the river, then mixed vertically within 1 km. Lateral mixing was very slow: at high flows in August 1989, the plume was still discernible 13 km downstream of the well outfall. The plume appeared to extend further towards the centre of the river at low flow (May 1989) than at high flow (August 1989), at a given site. Concentrations and composition of hydrocarbons were similar immediately upstream and immediately downstream of the well. None of the Peace River samples collected for Microtox testing was toxic.

Variations in the composition of the benthic invertebrate community in the 30 km downstream of the oil well were related to variations in substrate characteristics rather than to the effects of the oil well. However, invertebrates collected within 100 m downstream of the well were considerably less diverse and somewhat less abundant than invertebrates collected 100 m upstream of the well. This implies that the well outflow has some local adverse effects on river biota.

Effects on Crops and Soils

Crops on land immediately to the north and to the south of the lease area and crops on land within the lease area exhibited poor growth or no growth at all. This condition was associated with sour smelling gas in the topsoil and subsoil, high chloride levels in the topsoil, high SAR (sodium adsorption ratio) and EC (electric conductance) and poor soil texture. Crop growth further to the south and east of the lease area was used as a control and rated as poor to excellent.

Alleged saltwater contamination of soil and groundwater and the development of "sinkholes" were investigated in the vicinity of the Peace River Oils No. 1 Well in July, 1989. Note that the water in "sinkholes" was not sampled because the depressions had been plowed over and seeded to wheat, as in the rest of the field. An electromagnetic (EM) survey was run around the oil well to include a line along the Peace River, and a traverse across a flood-plain and along a flood water channel at the base of the east valley slope where a blow-out cavity was located. Measurements were made at 3 and 6 m depth. This survey also included a line that traversed a collapse feature, thought to be a "sinkhole".

Oil and saltwater seepage has long been observed in the Peace River valley. Natural contamination is therefore expected in valley soils and groundwater in variable quantities.

STUDY PERSONNEL

B. Jackson and J. Willis collected the samples from the Peace River, the Peace River Oils #1 Well and some of the samples from Nixon's old domestic well. M. de Brentani collected samples from Nixon's old domestic well for routine water analyses and carried the electromagnetic survey out with the assistance of E. Lorberg. A. Jans collected soil samples and carried the on-site soil and crop inspection.

Water quality samples were analyzed at the Alberta Environmental Centre (AEC) under the supervision of F. Dieken and D. Smillie.

Microtox samples were processed at the AEC under the supervision of A.A. Qureshi.

Benthic invertebrate samples were processed by W.J. Anderson with the assistance of M. Mychajluk and R. Casey.

Data were analyzed and the report prepared by A.M. Anderson, M. de Brentani, A. Jans, and E. Lorberg, with the assistance of L. Noton and D. Trew.

The report was typed by L. Lockhart and the figures were drafted under the supervision of T. Zenith (Design and Construction Division).

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1.0 INTRODUCTION

This report summarizes the results of investigations carried out by the Environmental Protection Services at the site of a long-term, continuously flowing, and abandoned oil well on the valley floor of the Peace River. The following information was extracted from memoranda from Morin (1989) and from Ozoray (1989), and provides historical background to this issue.

The Peace River Oils #1 Well (LSD 4-31-85-20-W5M) was drilled in 1916 in an attempt to locate hydrocarbons in the Peace River Formation. Most of the wells drilled in the earlier part of the century were abandoned in the mid-1950's. The ERCB made two costly, but unsuccessful attempts to abandon the Peace River Oils #1 Well. During one of these attempts salt water from the well spilled over adjoining crop land.

The well is located on the right bank of the Peace River about 20 km downstream of Peace River. It is discharging 30 to 50 l/s of salt water into the Peace River. Natural gas, containing 1% hydrogen sulphide, escapes in sufficient amounts to support a continuous flame at the well head. The salt water which is under pressure experiences a pressure gradient towards the river and may enter the river in other places than the well site. Salt water has been observed to enter the river in a backwater one quarter mile away from the well site. Salt water can also enter the Quaternary deposits which are a major aquifer in the area.

The investigation of environmental effects of the flowing well was initiated in response to a request from the ERCB who has in turn responded to complaints from the current landowner.

The purpose of this investigation was to:

1. assess the quality of Peace River Oils #1 Well outflow and to monitor the hydrogen sulphide emissions;
2. assess the impact of this water on the Peace River;
3. compare the quality of Nixon's old domestic well water with that of the oil well effluent;
4. assess the effects of the well on nearby soils and vegetation, and
5. assess the origin of alleged "sinkholes".

2.0 METHODS

Methods outlined in this section pertain to the sampling of the Peace River, the flowing well and Nixon's old domestic well. Methods pertaining to other components of the Peace River Oils #1 Well study are outlined in Appendices 7 to 10.

2.1 PEACE RIVER OILS #1 WELL SAMPLING

Peace River Oils #1 Well was sampled on four occasions by the Environmental Quality Monitoring Branch to assess the quality of the outflowing water: May 17 and October 4, 1988, and March 1 and May 24, 1989. The first two samples were collected in the course of synoptic survey work on the Peace River, whereas the latter two were collected as part of the study of the flowing well. On these dates grab samples were collected for the analysis of major inorganic and organic constituents, nutrients, and metals. A complete list of field procedures and analytical methods is given in Appendix 1. Analyses of routine chemistry samples of the Peace River Oils #1 Well, and of other samples

collected in this study were performed by Chemex Labs Inc. However, samples collected in more recent surveys (conducted in July and August 1989) were analyzed at the Alberta Environmental Centre (AEC).

Samples for the analysis of trace organic compounds were collected on all dates except March 1, 1989. Both volatile and semi-volatile trace organic compounds listed in Appendix 2 and 3 were analyzed following the United States Environmental Protection Agency analytical protocols (USEPA 1986.). All trace organic constituents were analyzed by AEC.

On August 9, 1989, samples were taken for hydrocarbon quantification (electronic integration with gas chromatograph and carbon counter), and finger printing (time basis over 45 minute period). Samples for volatile and semi-volatile priority pollutants and for Microtox testing[1] were collected as well. Data were interpreted according to the CCREM (1987) guidelines because they are user specific.

2.2 SAMPLING OF NIXON'S OLD DOMESTIC WELL

Nixon's old domestic well was sampled on two occasions (July 25 and August 9, 1989) with a peristaltic pump and new tubing equipped with a footvalve, at a depth of approximately 20 feet. A small volume of water was pumped out of the well before collecting the samples.

Sampling on July 25 included hydrocarbons, and semi-volatile priority pollutants. On August 9, 1989 samples were collected for

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[1] Microtox is a microbial assay based on the measurement of light output by luminescent bacteria. The test has been used worldwide for toxicity assessment of chemicals, complex effluents, and a wide variety of environmental samples (Dr. A.A. Qureshi, pers. comm.).

hydrocarbon finger printing, volatile and semi-volatile priority pollutants and Microtox testing.

2.3 PEACE RIVER WATER QUALITY SAMPLING

2.3.1 Water Quality in a 50 km Stretch Below the Oil Well

The Peace River was surveyed extensively for baseline water quality data from May 1988 to March 1989 as part of a larger, basin-wide synoptic survey. Although that program was not intended to assess the impact of the Peace River Oils #1 Well, some of the data can be used to assess potential, larger-scale effects of the well water on Peace River water quality. River data are available for cross-channel transects at the following locations (Figure 1 and Table 1):

1. downstream of the proposed pulp mill site and upstream of the well;
2. upstream of the Whitemud River confluence, and
3. east of Manning.

Data were collected from each site on May 17 and October 4, 1988 and March 1, 1989.

2.3.2 Water Quality in the Immediate Vicinity of the Oil Well

On May 24, 1989 detailed cross-channel transects for field variables were measured with a Hydrolab 4041 at the following locations in the immediate vicinity of the well (Figure 2A):

- 100 m upstream of the well
- 100 m downstream of the well
- 1 km downstream of the well

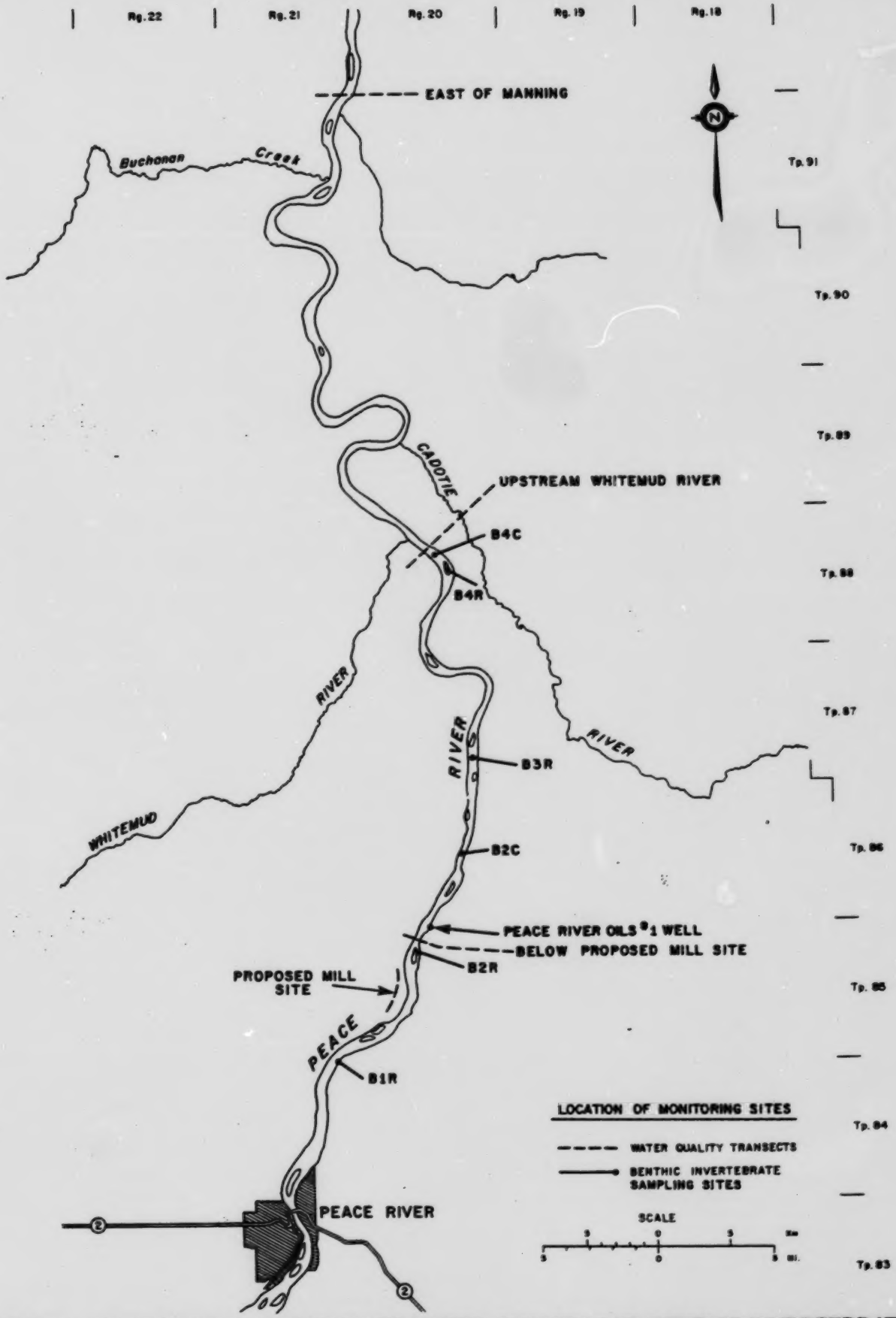

FIGURE 1 PEACE RIVER: LOCATION OF WATER QUALITY AND BENTHIC INVERTEBRATE MONITORING SITES PERTINENT TO THE PEACE RIVER OILS #1 WELL STUDY.

TABLE 1. NAQUADAT (Environment Canada, 1986) Codes and Site Description of Peace River Monitoring Sites Pertinent to the Peace River Oils #1 Study

River	Site Description	NAQUADAT Code
Water Quality Sites		
Peace River Oils #1 Well		00AL07HA2400
Peace River d/s Proposed Pulp Mill (Transect)	- Left	00AL07HA2500
	- Left Center	00AL07HA2510
	- Center	00AL07HA2520
	- Right Center	00AL07HA2530
	- Right	00AL07HA2540
Peace River Above Whitemud River (Transect)	- Left	00AL07HA2800
	- Left Center	00AL07HA2810
	- Center	00AL07HA2820
	- Right Center	00AL07HA2830
	- Right	00AL07HA2840
Peace River East of Manning (Transect)	- Left	00AL07HC1000
	- Left Center	00AL07HC1010
	- Center	00AL07HC1020
	- Right Center	00AL07HC1030
	- Right	00AL07HC1040
Benthic Invertebrate Sites		
Peace River 4 km u/s Proposed Mill (B1R)		00AL07HA2100
Peace River 2 km d/s Proposed Mill (B2R)		00AL07HA2200
Peace River 7 km d/s Proposed Mill (B2C)		00AL07HA2620
Peace River 20 km d/s Proposed Mill (B3R)		00AL07HA2660
Peace River 32 km d/s Proposed Mill (B4R)		00AL07HA2680
Peace River 33 km d/s Proposed Mill (B4C)		00AL07HA2700

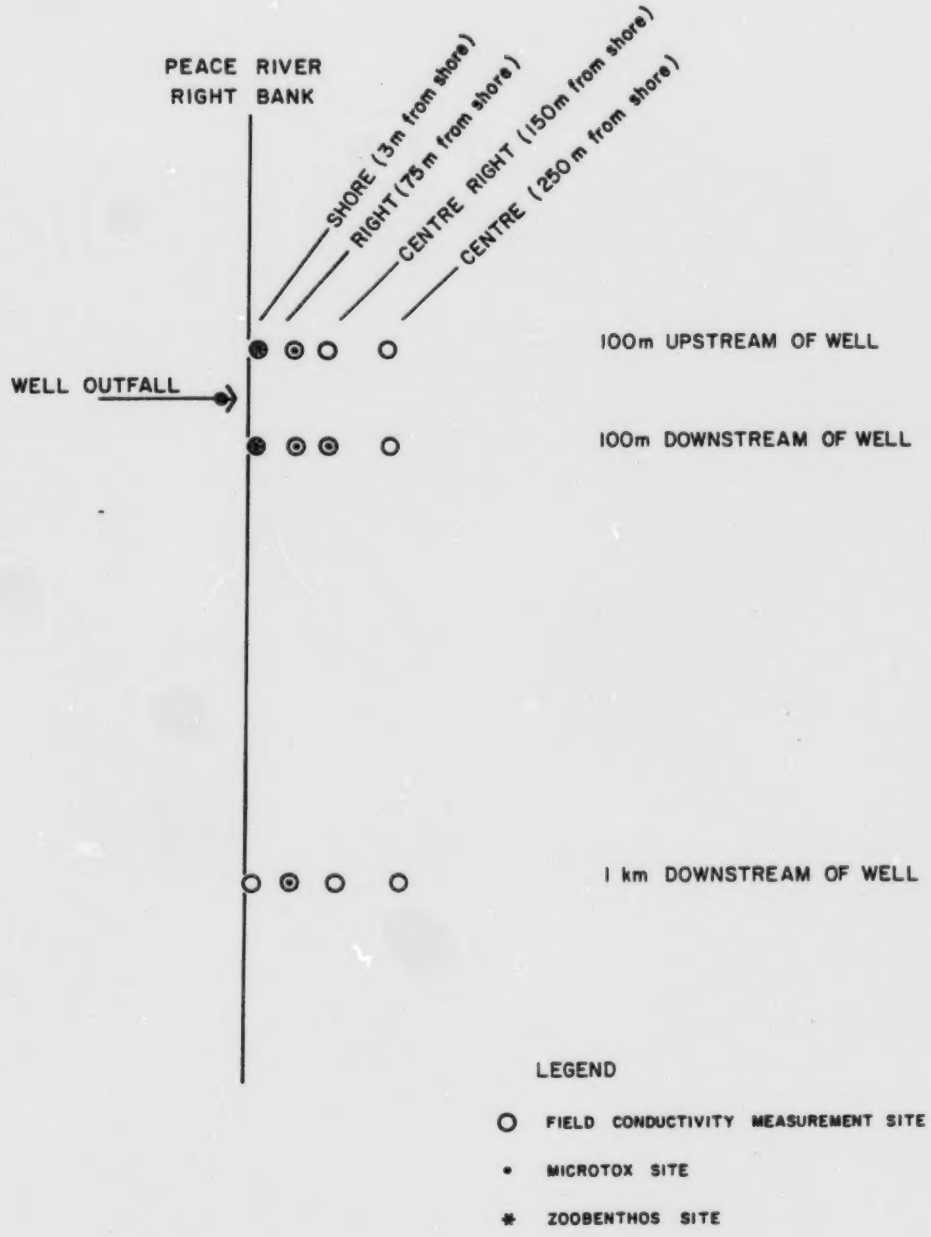

FIGURE 2A PEACE RIVER : SCHEMATIC PRESENTATION OF SAMPLING LOCATIONS IN THE IMMEDIATE VICINITY OF THE PEACE RIVER OILS #1 WELL MAY 24, 1989.

Samples were collected in the centre of the channel (i.e. 250 m from shore), to the right of the center channel (i.e. 150 m from shore), along the right bank (i.e., 75 m from shore), and along the right shore (i.e., 3 m from shore).

A second survey was carried out on August 9, 1989. On this occasion, conductivity measurements were carried out near the surface along cross-sectional transects as far as 13 km below the well (Figure 2B). Maximum conductivity was recorded along each cross-section. Conductivity was also recorded at fixed distances from the shore (i.e., 3 m, 30 m, 75 m, and 150 m), 100 m upstream and 100 m downstream of the well and along selected transects below the well (i.e., 1 km, 6 km, 12 km, and 13 km). A vertical profile was taken 3 m and 30 m from the shore along these selected transects. Microtox samples and hydrocarbon samples were also collected at these sites. Hydrocarbon samples for finger printing were taken 100 m upstream and 100 m downstream from the well outfall at 3 and 30 m from the shore.

2.4 ZOOBENTHOS

2.4.1 Field Methods

2.4.1.1 Zoobenthos in a 30 km Stretch Downstream of the Oil Well

Benthic invertebrate surveys were part of the 1988-89 basin synoptic survey carried out on the Peace River. Note that benthic invertebrate and water quality sites do not necessarily correspond and that water quality samples were collected further downstream. Some of the benthic invertebrate data collected on October 4, 1988 are pertinent to the Peace River Oils #1 Well study as the sampling sites are located

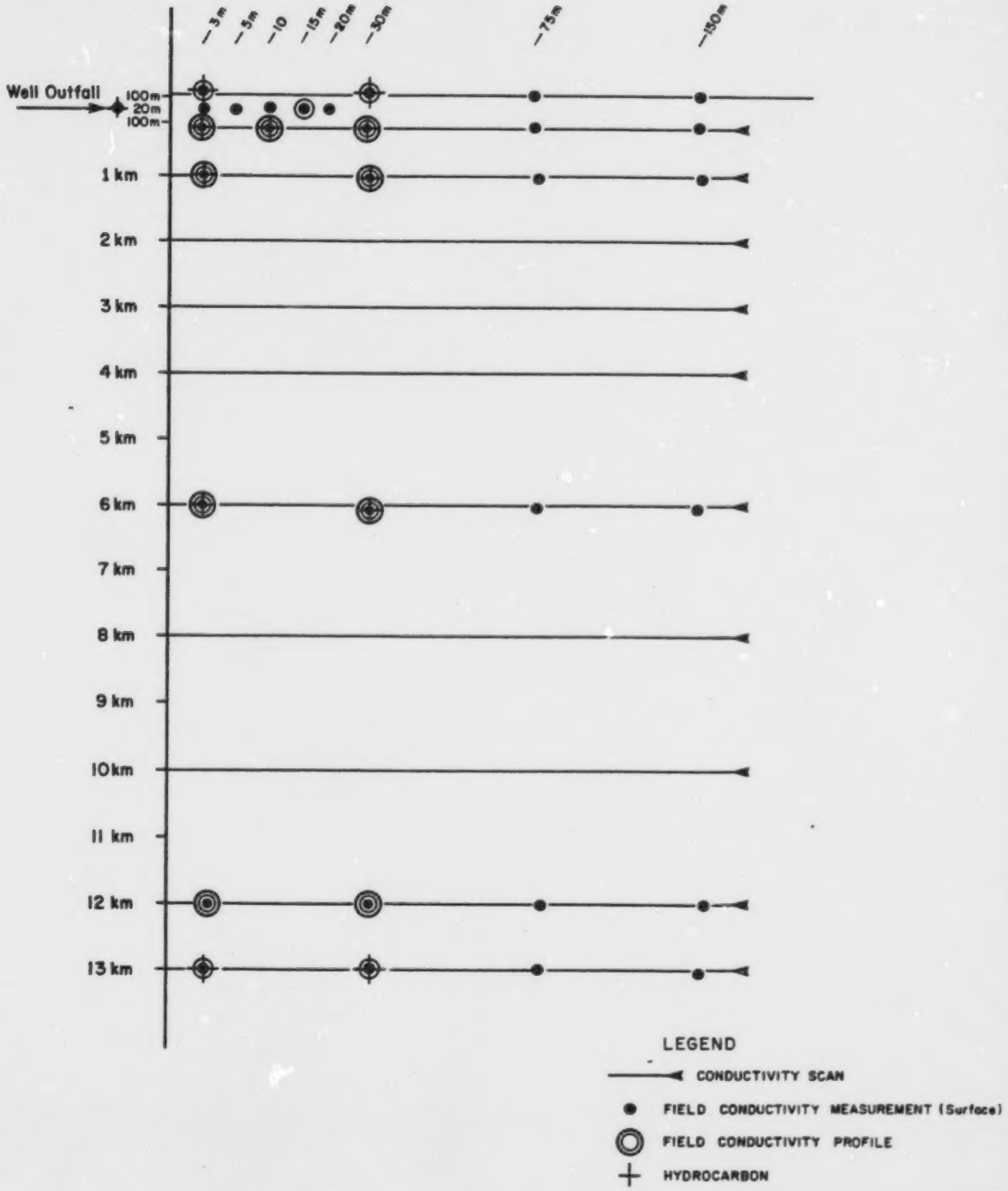

FIGURE 2B PEACE RIVER : SCHEMATIC PRESENTATION OF SAMPLING LOCATIONS IN IMMEDIATE VICINITY OF THE PEACE RIVER OILS #1 WELL - AUGUST 9, 1989.

in the presumed mixing zone of the well water (Figure 1). If impacts from the well water are severe, benthic invertebrates will respond by changes in population density, community composition and species diversity (number of taxa).

A Neill cylinder sampler (area 0.1 m^2) equipped with a collecting net of 0.210 mm mesh aperture was used to collect five replicate samples at each site. The habitat sampled was erosional gravel and cobble. The substrate within the cylinder was thoroughly disturbed for 1 minute and larger rocks were individually cleaned into the cylinder. Samples were preserved in 4% formaldehyde. Although efforts were made to standardize sampling sites with regard to substrate, depth, and current velocity, inter-site differences which could induce differences in zoobenthos are often unavoidable. In order to document such differences, measurements of sampling depth, flow velocity, and substrate size distribution (expressed as % of total weight) were carried out for every replicate and averaged to represent the sampling site.

2.4.1.2 Zoobenthos in the Immediate Vicinity of the Oil Well

On May 24, 1989 two sets of five Ekman dredges (22.5 cm x 22.5 cm) were collected in the immediate vicinity of the well (i.e., 100 m upstream and 100 m downstream of the well). Samples were collected from fine, silty substrate which dominates the river bed near the well site. Samples were sieved in the field (0.400 mm mesh size) and preserved in 4% formaldehyde.

2.4.2 Laboratory Methods

Invertebrates samples were stationed with Rose Bengal (Mason and Yevich 1967). Invertebrates were sorted under a dissecting scope. Specimens were counted and identified according to Bauman et al. (1977), Edmunds et al. (1976), Merritt and Cummins (1984), Pennak (1978) and Wiggins (1977).

2.4.3 Data Analysis

Several benthic invertebrate descriptors were examined since reliance on only one may lead to mis-interpretation. Variables taken into consideration include: total number of invertebrates, total number of taxonomic groups and the distribution of major taxonomic groups.

When a benthic community is affected by effluent discharges, changes may occur in the number of taxa and/or the density of organisms. An effluent with an enrichment effect could induce increases in population densities and taxonomic diversity whereas a toxic effluent could have the opposite effect. Hocutt (1975) believes that a simple ordination of numbers of invertebrates against number of taxa can describe such effects and can be used to assess stress in a benthic invertebrate community.

3.0 RESULTS AND DISCUSSION

Results presented in this section pertain to the analyses of samples from the Peace River, the flowing well and the old domestic well. Results of other components of the Peace River Oils #1 Well study are presented in Appendices 7 to 10.

3.1 PEACE RIVER OILS #1 WELL WATER QUALITY

3.1.1 Routine Chemistry

Results of well water analyses for May 1988 to May 1989 are listed in Tables 2 to 6. The well water which enters the Peace River has very high sodium and chloride ion concentrations with means of 11950 mg/L Na^+ and 17463 mg/L Cl^-. The bicarbonate concentration is also fairly high (mean: 3147 mg/L), but concentrations of other major ions are not elevated. The high sodium and chloride ion concentrations account for the high total dissolved solids (TDS) concentration which is of the order of 32,000 mg/L. Because of this high salt concentration the water that flows out of the well is classified as saline (McNeely et al. 1978). Associated with the high ionic concentrations is a specific conductance value of approximately 60,000 µmhos/cm.

The water also contains high concentrations of barium (mean 35.38 mg/L), boron (mean 12.95 mg/L), lithium (mean 4.458 mg/L), strontium (mean 51.88 mg/L) and ammonia (mean 25.62 mg/L). Sulphide was also present, at concentrations of 0.76 and 3.33 mg/L. Other water quality parameters listed in Table 2 were not at concentrations of concern.

Because of its high salt concentration the well water would be totally unsuitable for irrigation of most crops (CCREM 1987). The salt concentration is high enough to affect aquatic biota, but considering the high dilution capacity of the Peace River, effects would likely be very localized (see Section 3.4).

Boron is transported into solution through the weathering of igneous and sedimentary rocks. Concentrations in the well water exceeded

TABLE 2. Peace River Oils #1 Well: Water Quality Data

Parameter Description	NAQUADAT Code	May 17/88	Oct. 4/88	March 1/89	May 24/89
Calcium	20103L	127.00	19.70	87.00	211.00
Magnesium	12102L	147.00	108.00	153.00	160.00
Sodium	11103L	11500.00	12000.00	12600.00	11700.00
Potassium	19103L	158.00	172.00	154.00	148.00
Chloride	17203L	18050.00	17400.00	17200.00	17200.00
Sulphate	16306L	57.9	81.0	174.0	120.0
PP Alkalinity as $CaCO_3$	10151L	623.0	L 0.1	L 0.1	L 0.1
Total Alkalinity as $CaCO_3$	10101L	2613.00	2970.00	3130.00	2860.00
pH	10301L	9.66	7.73	8.16	8.10
Carbonate	06301L	747.6	L 0.5	L 0.5	L 0.5
Bicarbonate	06201L	1666.4	3620.4	3815.5	3486.3
Total Hardness as $CaCO_3$	10602L	922.6	493.8	847.2	1186.1
Hydroxide	08501L	-	L 0.5	L 0.5	L 0.5
Fluoride	09107L	1.52	1.75	2.30	1.70
Silica, Reactive	14105L	5.00	4.30	4.54	2.77
Specific Conductance	02041L	61600.00	-	-	59900.00
Turbidity	02074L	1.9	0.4	20.0	18.0
Colour (True)	02021L	L 5.	20.	10.	5.
Oil & Grease - Freon (IR)	06521L	L 0.1	3.3	3.6	0.3
Cyanide	06608L	L 0.1	3.3	3.6	0.3
Phenols	06537L	0.150	0.002	0.160	0.140
Sulphide	16200L	-	-	3.33	0.76
Total Organic Carbon	06005L	7.0	9.3	7.11	8.0
Dissolved Organic Carbon	06104L	6.6	8.7	6.2	7.7
Total Ammonia Nitrogen	07505L	27.00	25.50	16.00	34.00
Total Kjeldahl Nitrogen	07015L	28.00	27.80	27.20	34.50
Nitrite Nitrogen as N	07206L	L 0.003	-	-	-
Nitrite Nitrate Nitrogen as N	07110L	L 0.003	-	-	-
Total Phosphorus as P	15406L	0.012	0.007	0.010	0.010
Total Filterable Residue	10451L	31650.	31600.	32300.	31300.
Non-Filterable Residue	10401L	50.0	10.8	15.6	28.4
Aluminum	13003L	0.03	0.02	0.02	0.02
Antimony	51103L	0.0011	L 0.0002	L 0.0002	L 0.0002
Arsenic	33005L	L 0.0002	0.0005	0.0012	L 0.0002
Barium	56001L	32.00	29.00	40.00	40.50
Beryllium	04002L	0.005	L 0.001	L 0.001	0.001
Boron		13.00	13.20	12.00	13.60
Cadmium	48002L	L 0.001	L 0.001	L 0.001	L 0.001
Chromium	24004L	L 0.001	L 0.001	L 0.001	0.002
Cobalt	27002L	L 0.001	L 0.001	L 0.001	L 0.001
Copper	29005L	0.001	L 0.001	0.004	L 0.001
Iron	26004L	-	0.02	-	0.17
Lead	82002L		L 0.002	L 0.002	L 0.002
Lithium	03001L	5.100	5.170	5.450	2.110
Manganese	25004L	0.054	0.040	0.048	0.040
Mercury	80011L	L 0.05	L 0.05	L 0.05	L 0.05
Molybdenum	42006L	0.013	0.007	0.001	L 0.001
Nickel	28002L	0.001	L 0.001	L 0.001	L 0.001
Selenium	34005L	L 0.0002	L 0.0002	0.0003	L 0.0002
Silver		L 0.001	L 0.001	0.002	0.002
Strontium	38001L	50.00	55.50	41.00	61.50
Vanadium	23002L	0.003	L 0.001	L 0.001	0.001
Zinc	30005L	0.005	0.007	0.003	L 0.001
Ion Balance	00103L	0.93	0.97	1.03	0.99
Peace River Discharge		3450	1340	1010	1770
Dilution Effluent in River		1:8620	1:33500	1:25250	1:44250

* units are mg/L, except for pH (pH units), Specific Conductance (µmhos/cm), Turbidity (NTU), Colour (PtCo Units) and Discharge (m^3/s)
* estimated discharge at oil well: 0.04 m^3/s

TABLE 3. Peace River Oils #1 Well: Semi-Volatile Compounds (µg/L) Identified in the Well Water

NAQUADAT NUMBER		MAY 17 1988	OCT. 9 1988	MAY 24 1989
95000	Benzoic Acid	2.U	2.U	2.U
95001	4-Chloro-3-Methylphenol	1.U	1.U	1.U
95002	2-Chlorophenol	2.U	2.U	2.U
95003	2,4-Dichlorophenol	1.U	1.U	1.U
95004	2,4-Demethyl Phenol	0.X	2.U	2.U
95005	2-Methyl-4, 6-Dinitrophenol	1.U	1.U	1.U
95006	2,4-Dinitrophenol	1.U	1.U	1.U
95007	Hexadecanoic Acid	3.U	3.U	4.
95008	2-Nitrophenol	1.U	1.U	1.U
95009	4-Nitrophenol	1.U	1.U	1.U
95010	Pentachlorophenol	1.U	1.U	1.U
95011	Phenol	0.X	1.U	1.U
95012	2,4,5-Trichlorophenol	1.U	1.U	1.U
95013	2,4,6-Trichlorophenol	1.U	1.U	1.U
95014	Acenaphthene	1.U	1.U	1.U
95015	Acenaphthylene	1.U	1.U	1.U
95016	Anthracene	0.X	1.U	1.U
95017	Benz(a)Anthracene	1.U	1.U	1.U
95018	Benzo(k)Fluoranthene	1.U	1.U	1.U
95019	Benzo(ghi)Perylene	2.U	2.U	2.U
95020	Benzo(a)Pyrene	1.U	1.U	1.U
95021	Chrysene	1.U	1.U	1.U
95022	Dibenzo(ah)Anthracene	5.U	5.U	5.U
95023	Fluoranthene	1.U	1.U	1.U
95024	Fluorene	1.U	1.U	1.U
95025	Indeno(1,2,3-cd)Pyrene	1.U	1.U	1.U
95026	Naphthalene	0.X	0.X	1.U
95027	Perylene	1.U	1.U	1.U
95028	Phenanthrene	0.X	1.U	1.U
95029	Pyrene	1.U	1.U	1.U
95031	Benzo(b)Fluoranthene	1.U	1.U	1.U
95032	2-Chloronaphthalene	0.X	1.U	1.U
95033	Hexachlorobenzene	1.U	1.U	1.U
95034	Hexachlorobutadiene	5.U	5.U	5.U
95035	Hexachlorocyclopentadiene	1.U	1.U	1.U
95036	Hexachloroethane	5.U	5.U	5.U
95037	1,2,4-Trichlorobenzene	1.U	1.U	1.U
95030	Isophorone	1.U	1.U	1.U
95038	Benzidine	2.U	2.U	2.U
95039	2,4-Dinitrotoluene	1.U	1.U	1.U
95040	2,6-Dinitrotoluene	1.U	1.U	1.U
95041	1,2-Diphenylhydrazine	1.U	1.U	1.U
95042	Nitrobenzene	1.U	1.U	1.U
95043	N-Nitrosodiphenylamine	1.U	1.U	1.U
95044	N-Nitroso-Di-n-Propylamine	2.U	2.U	2.U
95045	4-Bromophenyl Phenyl Ether	1.U	1.U	1.U
95046	Bis(2-Chloroethoxy)Methane	1.U	1.U	1.U
95047	Bis(2-Chloroethyl)Ether	1.U	1.U	1.U
95048	Bis(2-Chloroisopropyl)Ether	1.U	1.U	1.U
95049	4-Chlorophenyl Phenyl Ether	1.U	1.U	1.U
95050	Butylbenzylphthalate	1.U	1.U	1.U
95051	Dibutylphthalate	0.X	1.X	1.X
95052	Diethylphthalate	0.X	1.U	0.X
95053	Dimethylphthalate	1.	1.U	1.U
95054	Di-n-Octylphthalate	1.U	1.U	1.U
95055	Bis(2-Ethylhexyl)-Phthalate	1.U	1.U	1.U

* U indicates compound was not detected; detection limit specified.
X indicates compound was detected; concentration specified.

TABLE 4. Peace River Oils #1 Well: Volatile Compounds (µg/L) Identified in the Well Water

NAQUADAT NUMBER		MAY 17 1988	OCT. 9 1988	MAY 24 1989
95200	Benzene	1	0.X	1.X
95230	Bromochloromethane	1.U	1.U	
95201	Bromodichloromethane	1.U	1.U	1.U
95202	Bromoform	5.U	5.U	5.U
95203	Bromomethane	1.U	1.U	1.U
95204	Carbontetrachloride	1.U	1.U	1.U
95205	Chlorobenzene	1.U	1.U	1.U
95206	Chloroethane	1.U	1.U	1.U
95207	2-Chloroethoxyethylene	4.U	4.U	4.U
95208	Chloroform	3.	1.U	1.U
95209	Dibromochloromethane	1.U	1.U	1.U
95211	1,2-Dichlorobenzene	1.U	1.U	1.U
95212	1,3-Dichlorobenzene	1.U	1.U	1.U
95213	1,4-Dichlorobenzene	1.U	1.U	1.U
95214	1,1-Dichloroethane	1.U	1.U	1.U
95215	1,2-Dichloroethane	1.U	1.U	1.U
95216	1,1-Dichloroethylene	1.U	1.U	1.U
95217	trans-1,2-Dichloroethylene	1.U	1.U	1.U
95218	1,2-Dichloropropane	1.U	1.U	1.U
95219	cis-1,3-Dichloropropylene	3.U	3.U	3.U
95220	trans-1,3-Dichloropropylene	3.U	3.U	3.U
95221	Ethylbenzene	1.U	1.U	0.X
95222	Methylene Chloride	1.8	4.8	2.8
95223	Styrene	1.U	1.U	1.U
95224	1,1,2,2-Tetrachloroethane	1.U	1.U	1.U
95225	Tetrachloroethylene	3.U	3.U	3.U
95226	Toluene	1.U	1.U	1.U
95227	1,1,1-Trichloroethane	1.U	1.U	1.U
95228	1,1,2-Trichloroethane	1.U	1.U	1.U
95231	Trichloroethylene	1.U	1.U	1.U
95229	Trichlorofluoromethane	1.U	1.U	1.U
95232	Vinyl Chloride	30.U	30.U	30.U
95233	o-Xylene	1.U	1.U	1.U
95234	m,p-Xylene	1.U	1.U	1.U

* U indicates compound was not detected, detection limit specified.
  X indicates compound was detected, concentration specified.

TABLE 5. Peace River Oils #1 Well: Tentatively Identified Compounds

	COMPOUNDS	µg/L
	VOLATILE COMPOUNDS	
May 17, 1988	1) Alkyl Benzenes (6-8 Isomers C9H12 Range)	5.X
	2) Dihydromethyl Naphthalenes	2.X
October 9, 1988	1) N-Nitrosodiphenylamine	0.X
	SEMI-VOLATILE COMPOUNDS	
May 17, 1988	1) Methyl Naphthalenes	4.X
	2) 2-Haptanone-3-Propylidene	2.X
	3) Sulphur (S6)	20.X
	4) Sulphur (S8)	2.X
October 10, 1988	1) Hydrocarbons	600.X

* X indicates compound was detected, concentration specified.

TABLE 6. Peace River Oils #1 Well: Hydrocarbons Identified in the Well Water

May 1988	Hydrocarbon (Crude Oil)	0.32 mg/L
October 1988	Hydrocarbon (Crude Oil)	0.57 mg/L
July 1989	Hydrocarbon (Crude Oil)	31.2 mg/L
August 1989	Hydrocarbon (Crude Oil)	2.3 mg/L

agricultural guidelines proposed by CCREM (1987) for irrigation (i.e. 6.0 mg/L) and livestock watering (i.e. 5.0 mg/L) as well as the Alberta Surface Water Quality Objectives (i.e. 0.5 mg/L). There are no CCREM guidelines for the protection of aquatic life, but McNeely et al. (1978) indicate that concentrations greater than 5.0 mg/L constitute a hazard to the marine environment. Boron concentrations in the Peace River were 0.03 and 0.04 mg/L at the site above Whitemud River on June 20, 1988 and March 1, 1989, respectively. Such concentrations are well within guidelines.

Lithium leaches easily from rocks and sediments and occurs in association with sodium in aqueous solution (McNeely et al. 1978). High lithium concentrations can be phytotoxic and guidelines of 2.5 mg/L or less are proposed by CCREM for irrigation water. The well water generally exceeded this guideline. There are no data regarding the Peace River lithium concentration in the area of the well. Lithium concentrations at Dunvegan ranged from <0.005 to 0.021 mg/L (NAQUADAT database). The predicted concentration increase of lithium, based on a conservative mass balance, in the Peace River, corresponds to 0.0002 mg/L (March 1, 1989 low flow) or to 0.00006 mg/L (May 17, 1989 high flow).

Barium weathers from igneous rocks and usually occurs in trace amounts in groundwater. Barium salts are highly toxic to humans and guidelines for drinking water have been set at 1.0 mg/L. There are no CCREM guidelines for agricultural usage. Although no guidelines exist for the protection of aquatic life, high concentrations of barium can affect rooted aquatic plants and many fish species (McNeely et al. 1979). Concentrations greater than 5 mg/L are harmful to many species of

fish (Environment Canada 1976, cited in McNeely et al. 1979). Barium concentrations in the well water were usually greater than 30.0 mg/L. In the Peace River concentrations above Whitemud River were 0.10 mg/L and 0.05 mg/L on June 20, 1988 and March 1, 1989, respectively. Based on a conservative mass balance, the contribution of barium from the flowing well would have amounted to an overall increase of 0.002 mg/L on March 1, 1989.

Strontium enters the aquatic environment through weathering of sedimentary rocks. There are no CCREM guidelines for strontium for drinking water, agricultural usage or protection of aquatic life. There are no data regarding the strontium concentration of Peace River water in the vicinity of the well. Strontium concentrations were monitored at Dunvegan from 1971 to 1980 and ranged from 0.05 to 0.25 mg/L (NAQUADAT database). Based on a conservative mass balance, the Peace River Oils #1 Well would have accounted for an overall concentration increase of 0.002 mg/L at low flow (March 1, 1989) or 0.0006 mg/L at high flow (May 17, 1989).

Un-ionized ammonia can be extremely toxic to fish and freshwater invertebrates. The toxicity of un-ionized ammonia varies with the pH and temperature, and the proportion of total ammonia that is un-ionized also varies with pH and temperature (CCREM 1987). Total ammonium nitrogen levels in the well water ranged from 16.00 to 34.00 mg/L. Considering the temperature and pH at which the samples were collected, ammonia levels in the oil well effluent should have remained under 2.5 mg/L to meet CCREM guidelines. Total ammonia measured in the Peace River along cross-channel transects upstream of the well, upstream of Whitemud River,

and east of Manning never exceeded 0.02 mg/L and were often below detection (i.e, <0.01 mg/L).

Hydrogen sulphide is a soluble, highly poisonous gas. Its toxicity is primarily related to the undissociated hydrogen sulphide (H_2S molecule). In natural waters sulphide ions rapidly oxidize to sulphate and concentrations are generally negligible in surface waters. There are no guidelines for the protection of aquatic life, but McNeely et al. (1979) indicate that hydrogen sulphide concentrations in excess of 0.002 mg/L are hazardous to fish and aquatic life. Because hydrogen sulphide readily oxidizes it is seldom monitored in surface waters and it is unlikely that toxicity problems would occur in the Peace River, with perhaps the exception of the area immediately below the outfall.

According to CCREM (1987) guidelines concentrations of total phenols should not exceed 0.001 mg/L to prevent tainting of fish flesh. Concentrations in the well water were usually in excess of this value and ranged from 0.002 mg/L to 0.160 mg/L.

3.1.2 Trace Organics

A number of trace organic compounds were also identified in the well water (Table 3 to 6). These include traces of organic priority pollutants such as chloroform, benzene, phenol, other phenolic compounds, and polycyclic aromatic hydrocarbons. Methylene chloride is a solvent used commonly in laboratories; concentrations shown in Table 4 are due to contamination in the lab and do not reflect concentrations in the oil well effluent. A list of tentatively identified volatile and semi-volatile compounds is presented in Table 5. Relatively little

information is available regarding their toxicity and no guidelines have been formulated for the protection of aquatic life. Consequently it is difficult to assess what the implications are of the traces found in the well water.

3.1.3 Microtox Testing

The three samples for Microtox testing collected from the oil well on May 24, 1989 and August 9, 1989 were extremely toxic. The sample concentration causing a 50% decrease in light production at 15°C after 15 minute exposure (15 min EC50) ranged from 3.2 to 7.3% (Table 7).

3.2 WATER QUALITY OF NIXON'S OLD DOMESTIC WELL

3.2.1 Routine Water Chemistry

Samples for routine water chemistry were collected by the Groundwater Protection Branch and results are discussed elsewhere (de Brentani 1989).

3.2.2 Trace Organics

Levels of hydrocarbons detected in Nixon's old domestic well ranged from 0.75 mg/L (August 9, 1989) to 1.2 mg/L (July 25, 1989). These hydrocarbons contained a light fraction (i.e., C6 to C8 or C9) which was not present in any other sample from the oil well or the Peace River. However, less volatile, heavier hydrocarbons (i.e. C12) matched the hydrocarbons found in the Peace River Oils #1 Well water sample. Heavier hydrocarbons from the domestic well and from the oil well are suspected to be from the same origin (R. Norton, Alberta Environmental

TABLE 7. Results of Microtox Test on Water From the Peace River Oils #1 Well, Nixon's Old Domestic Well, and the Peace River - Summarized from Reports Produced by Alberta Environmental Centre in Vegreville Under Supervision of Dr. A.A. Qureshi

Site Description	Microtox (Mx) 15 Min.EC50% Original Sample %	Toxicity Rank
Peace River Oils #1 Well (PRO#1)		
May 24, 1989		
Replicate 1	3.2	extremely toxic
Replicate 2	6.5	extremely toxic
August 9, 1989	7.3	extremely toxic
Nixon's Old Domestic Well		
August 9, 1989		
Replicate 1 Duplicate 1	26.8	very toxic
Duplicate 2	29.1	very toxic
Replicate 2	15.0	extremely toxic
Peace River		
May 24, 1989		
100 m u/s PRO #1 right bank	NTE	nontoxic
100 m d/s PRO #1 right bank	NTE	nontoxic
100 m d/s PRO #1 right-centre	NTE	nontoxic
1 km d/s PRO #1 right bank	NTE	nontoxic
August 9, 1989		
100 m u/s PRO #1, 3 m from shore	NTE	nontoxic
100 m u/s PRO #1, 30 m from shore	NTE	nontoxic
100 m d/s PRO #1, 3 m from shore	NTE	nontoxic
100 m d/s PRO #1, 10 m from shore	NTE	nontoxic
100 m d/s PRO #1, 30 m from shore	NTE	nontoxic
1 km d/s PRO #1, 3 m from shore	NTE	nontoxic
1 km d/s PRO #1, 30 m from shore	NTE	nontoxic
6 km d/s PRO #1, 3 m from shore	NTE	nontoxic
6 km d/s PRO #1, 30 m from shore	NTE	nontoxic
13 km d/s PRO #1, 3 m from shore	NTE	nontoxic
13 km d/s PRO #1, 30 m from shore	NTE	nontoxic

NTE - no toxic effect

Centre, pers. comm.) The analysis of semi-volatile priority pollutants revealed the presence of traces of phenol in the domestic well water.

3.2.3 Microtox Testing

The two samples from Nixon's old domestic well were analyzed separately. One sample was analyzed in duplicate and produced 15 minutes EC50's of 26.8% and 29.1%. The second sample had a 15 minute EC50 of 15%. Based on these EC50 values, the two samples were classified as very to extremely toxic (Table 7).

3.3 PEACE RIVER WATER QUALITY

3.3.1 Water Quality in a 50 km Stretch Below the Oil Well

As mentioned earlier (Methods section), the 1988-89 synoptic survey of the Peace River was not designed specifically to assess the impacts of the Peace River Oils #1 Well. As a result, many constituents which are typical of the well water have not been monitored in the river and a detailed assessment of the effects of the well water on the Peace River is not possible. There are some additional complicating factors in the assessment. The water volume discharged from the well is very small relative to that of the Peace River (1 to 10,000 at low river flow). The dilution factor is so large that for many constituents the contributions of the well would not be measurable in the river, particularly considering the long distance between the well and the first Peace River site for which extensive water quality data are available. The potential for interference from other sources such as natural flowing gas wells along the river is also considerable. Finally, some constituents of

concern in the well water are unstable and oxidize rapidly to innocuous constituents common in the receiving water.

Sodium and chloride are conservative ions which occur at high concentrations in the well water and which have been monitored along transects in the Peace River. Theoretically, the data could be used to determine lateral and longitudinal mixing patterns of saline well water in the Peace River which has low sodium and chloride concentrations. However, the mixing patterns of the Smoky and Whitemud rivers, both with sodium and chloride concentrations higher than the Peace River, overshadow the mixing patterns of the well water. Concentrations of chloride in the well are higher than concentrations of sodium in the well, but in the Peace River, chloride concentrations are lower than sodium concentrations. Therefore any effect of the well outflow on river concentrations should be more noticeable for chloride. Indeed, on all sampling occasions, chloride increased at all points along the transects upstream of Whitemud River compared to corresponding points along the transect upstream of the well (Table 8). The increases, about 0.2 - 1.5 mg/L, is consistent with the dilution of the well outflow (at 17,500 mg/L and 0.04 m^3/s) into the Peace River (at about 1800 m^3/s). Thus some overall increase in Peace River chloride may result from the well outflow, but the resulting concentrations would not affect the general water quality.

Conductivity measured in the immediate vicinity of the well provides a better indication of the oil well effluent mixing in the river.

TABLE 8. Peace River: Cross-channel Na^+ and Cl^- Concentrations ($mg \cdot L^{-1}$) and Specific Conductance ($\mu S \cdot cm^{-1}$) in the Vicinity of Peace River Oils #1 Well (May 24, 1989)

	Na^+					Cl^-					Conductivity				
	L	LC	C	RC	R	L	LC	C	RC	R	L	LC	C	RC	R
May 17, 1988															
Below proposed pulp mill effluent	3.20	3.20	3.20	3.50	3.80	0.50	0.50	0.50	0.80	1.10	199	199	199	205	207
Upstream Whitemud	2.60	2.80	3.00	3.50	3.80	0.60	0.70	1.00	1.30	1.70	196	199	201	203	206
East of Manning	4.30	4.20	4.30	4.20	4.20	1.20	1.00	0.90	0.80	0.80	209	208	208	208	208
October 4, 1988															
Below proposed pulp mill effluent	2.10	2.40	3.00	4.90	6.20	1.00	0.90	2.10	3.30	4.30	188	191	205	242	263
Above Whitemud River	2.70	3.50	4.70	5.20	5.80	1.60	1.90	2.90	3.90	4.40	194	207	222	228	232
East of Manning	3.40	3.70	3.90	4.10	4.40	2.20	2.40	2.50	2.80	3.10	207	206	213	217	220
March 1, 1989															
Below proposed pulp mill effluent	1.60	1.60	2.40	4.70	5.20	1.00	0.90	1.80	3.60	4.20	177	177	188	216	228
Above Whitemud River	2.00	2.70	3.40	4.00	4.60	1.40	2.30	3.30	3.80	4.70	181	188	NA	200	202
East of Manning	2.30	2.40	2.60	3.20	3.90	2.10	1.90	2.20	2.90	3.50	140	185	185	195	199

L left bank
LC left centre
C centre channel
RC right centre
R right bank

3.3.2 Water Quality in the Immediate Vicinity of the Oil Well

Lateral transects in the Peace River in the immediate vicinity of Peace River Oils #1 Well show that there was a sharp increase in conductivity 100 m downstream of the well on the right bank (i.e. approximately 75 m from shore) (Table 9). Conductivity was lower on the right bank 1 km below the well, but remained elevated along the shoreline.

On August 9, 1989 conductivity measurements along cross-channel transects showed elevated values in a 40 m wide zone along the right bank of the river. Highest conductivity readings near the surface were recorded immediately below the well outfall (i.e., 100 m downstream) at about 10 m from the shore (Table 10). Slight cross-channel conductivity gradients could still be detected as far downstream as 13 km below the well outfall.

Vertical profiles showed the existence of sharp gradients in the immediate vicinity of the well outfall with conductivity values at the bottom nearly twice as high as values near the surface of the water column (Table 10). Such gradients were not detected 1 km below the well or at any of the remaining sites further downstream.

Conductivity data indicate that the Peace River Oils #1 Well plume travels close to the right bank of the Peace River, mixes slowly with the river water, and can be traced over at least 13 km downstream of the outfall.

Apparently, the Peace River Oils #1 Well effluent sinks to the bottom upon its entry in the Peace River, but vertical mixing occurs a lot faster (less than 1 km) than lateral mixing. Surveys carried out in the vicinity of the well at relatively low and high Peace River discharge

TABLE 9. Peace River: Lateral Variability of Conductivity ($\mu S \cdot cm^{-1}$) in the Vicinity of Peace River Oils #1 Well, May 24, 1989

	Conductivity			
	Distance from Shore			
Distance from Oils #1 Well	3 m (Shore)	75 m (Right)	150 m (Right Centre)	250 m (Centre)
100 m upstream	N/A	212	213	213
100 m downstream	306	300	213	216
1 km downstream	301	263	213	217

TABLE 10. Peace River: Lateral and Vertical Variability of Conductivity in the Vicinity of Peace River Oils #1 Well, August 9, 1989

Conductivity ($\mu S \cdot cm^{-1}$)

Distance From Oils #1 Well	Distance From Shore									Maximum Recorded Near Surface Along Transect
	3 m	5 m	10 m	15 m	20 m	30 m	40 m	75 m	150 m	
100 m u/s	207					207		205	202	207
20 m d/s	254	246	261	0*:280 .5:495	209					
100 m d/s	0:262 .5:274		0:305 1:320			0:226 1:426 2:453	209	206	203	340
1 km d/s	0:308 .5:299					0:254 1:253 1.5:246		206	200	308
2 km d/s										268
3 km d/s										258
4 km d/s										249
6 km d/s	0:244 1:245 1.5:244					0:227 1:226 2:225 2.5:224		205	201	240
8 km d/s										226
10 km d/s										220
12 km d/s	0:218 1:218 1.5:218					0:210 1:213 2:213 3:213				220
13 km d/s	219					217		206	201	219

(*) depth in metres

suggest that lateral mixing patterns of the plume may differ depending on river flows. At the relatively low river discharge of 1770 m^3/s (May 24, 1989), the effluent plume was broader than at the higher discharge of 2747 m^3/s measured on August 9, 1989. The river discharge is also likely to affect the length of the plume.

3.3.2.1 Hydrocarbons

Samples collected on August 9, 1989 upstream of the well (3 m from shore) and 100 m downstream of the well (3 m and 10 m from shore) had hydrocarbon concentrations less than 0.05 mg/L. Finger printing showed that samples collected downstream of the well matched the sample collected above the well. In other words, contamination of the Peace River by the well effluent could not be demonstrated.

3.3.2.2 Microtox Testing

Microtox test results showed that all samples collected in the Peace River 100 m upstream of the well, and all samples collected downstream of the well outfall on May 24 and August 9, 1989 were non-toxic (Table 7). As discussed earlier, there are several constituents in the well water which occur at potentially toxic concentrations. The salinity of the well water could affect aquatic life forms adapted to fresh water and salinity could be a factor in the results obtained with trout bioassays by the ERCB in October 1985 (Appendix 4). However, it is unlikely that Microtox test organisms which are marine bacteria would be affected by the 3% salt concentration of the well water (Dr. R. Coleman, Alberta Environmental Centre, pers. comm.).

This statement is substantiated by the toxic response in Nixon's old domestic well, where the water is not saline. This suggests that constituents other than salts may be responsible for the toxicity. The Microtox test is non-specific and it is not possible to determine which constituent(s) account for toxicity. Levels of ammonia, sulphide, boron, barium, strontium and organic pollutants could induce toxic responses in Microtox organisms as single constituents or in combination (synergistic effects).

The absence of toxic response in the Peace River indicates that toxicity for Microtox organisms has dissipated through dilution or chemical transformations.

3.4 ZOOBENTHOS

3.4.1 Zoobenthos in a 30 km Stretch Below the Oil Well

When environmental stress such as a change in water quality affects benthic invertebrate communities, a change in population density, number of taxa and/or species composition may result. The simple ordination of total density against number of taxa proposed by Hocutt (1975) is useful in the recognition of stressed invertebrate communities.

Figure 3 presents such an ordination for the Peace River monitoring data. The two sites above the well (B1R and B2R) have a considerably larger population density and a somewhat higher number of taxa than any of the other sites. However, Table 11 illustrates the variability in physical habitat among benthic sampling sites, and Figure 4 shows that there is a strong positive relationship between population density and the proportion of cobble in the substrate. This

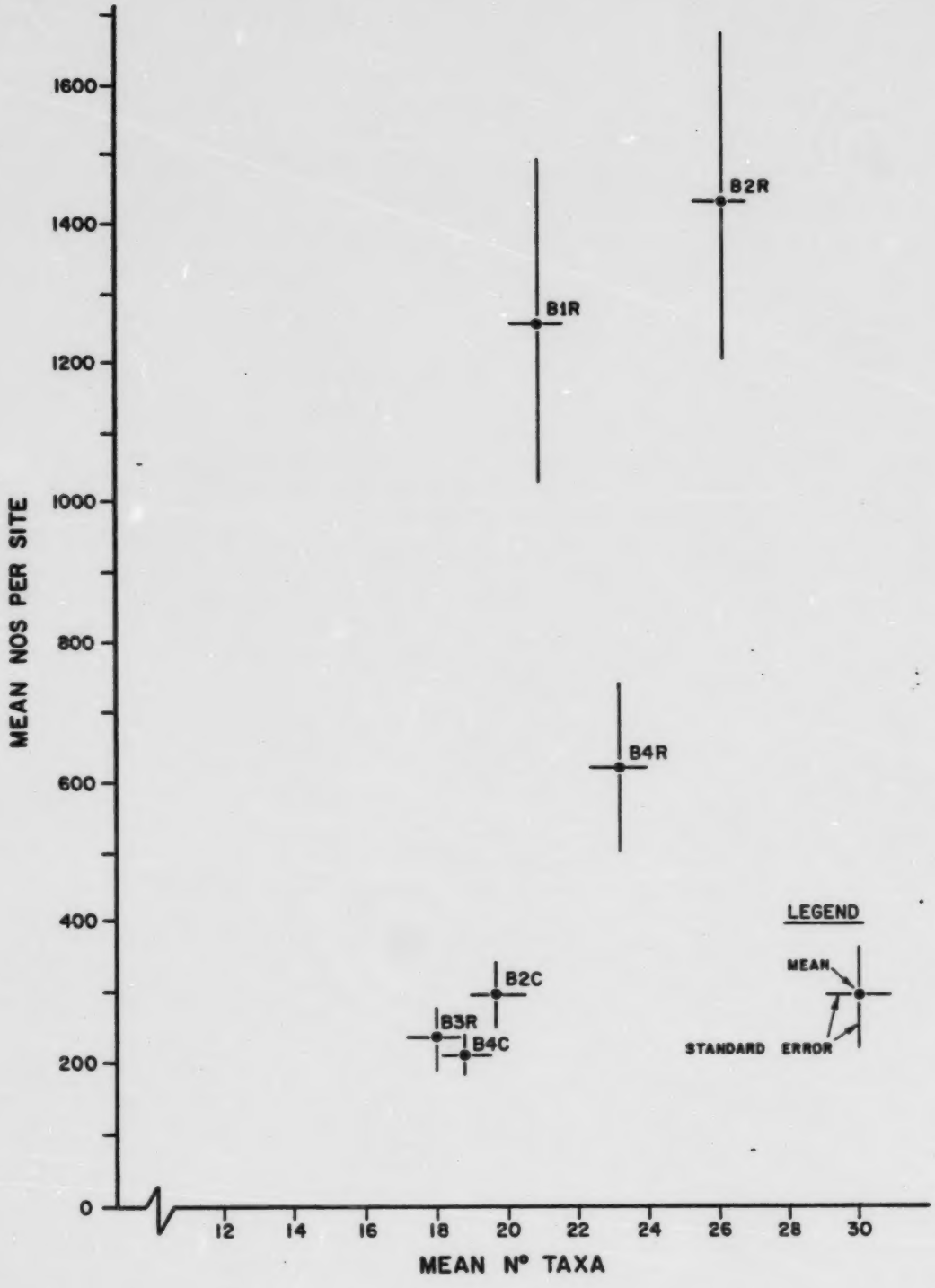

FIGURE 3 PEACE RIVER ZOOBENTHOS, OCTOBER 1988 : ORDINATION OF THE NUMBER OF INVERTEBRATE TAXA AND THE NUMBERS OF SPECIMENS.

TABLE 11. Peace River: Flow, Depth, and Substrate Characteristics at the Benthic Invertebrate Monitoring Sites (mean per site, n = 5)

	FLOW m/s	DEPTH cm	% COBBLE	% COARSE PEBBLE	% FINE PEBBLE	% SAND SILT
B1R	0.203	36.0	75.34	17.81	4.11	2.74
B2R	0.615	23.2	64.29	25.00	7.14	3.57
B2C	0.537	21.8	53.73	37.12	4.12	1.03
B3R	0.708	20.0	46.31	39.60	11.41	2.68
B4R	0.626	35.8	61.74	34.90	3.36	0
B4C	0.586	33.4	19.21	48.78	22.56	9.45

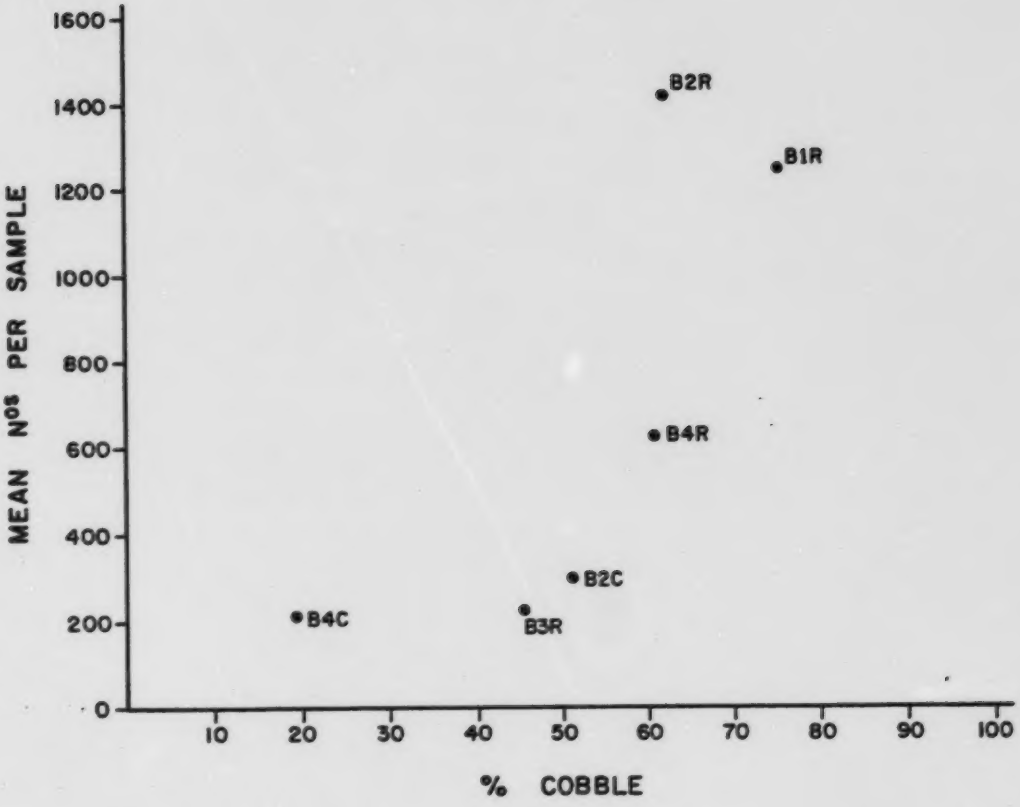

FIGURE 4 · PEACE RIVER, OCTOBER 1988 : RELATIONSHIP BETWEEN THE MEAN NUMBER OF INVERTEBRATES PER SITE AND THE PERCENT OF COBBLE IN THE SUBSTRATE.

concurs with the findings of Clement (1987) who, in addition, reports a positive relationship between substrate size and number of taxa. The relationship between the number of taxa and substrate characteristics was not as clear in our data set and there was some overlap in the number of taxa per site at sites upstream and downstream of the well. Therefore, it is probably that the differences in total density and number of taxa among sites are linked to differences in physical habitat; it is unlikely that the well water affects the zoobenthos at the sites monitored in the fall of 1988. Additional features in the zoobenthos support this assessment. Mayfly and stonefly species are generally believed to be very sensitive to a variety of changes in their environment, including water quality. Figure 5 shows that these taxa are not adversely affected at the monitoring sites as their density is often considerably higher downstream than upstream of the well.

3.4.2 Zoobenthos in the Immediate Vicinity of the Oil Well

The ordination of numbers against taxa (Figure 6) separates samples collected 100 m downstream of the well sharply from those collected 100 m upstream of the well, mainly because the number of taxonomic groups was considerably lower below the well. According to Hocutt's criteria, the fauna below the well site showed signs of stress. Additional features of the zoobenthos 100 m downstream of the well point in the same direction: tubificid worms and chironomid larvae represented 94% of the benthos (Figure 7): naidid worms, nematodes and ceratopogonids were the only other taxa present in the samples. Tubificidae and aquatic life stages of some Chironomidae are burrowing organisms and their

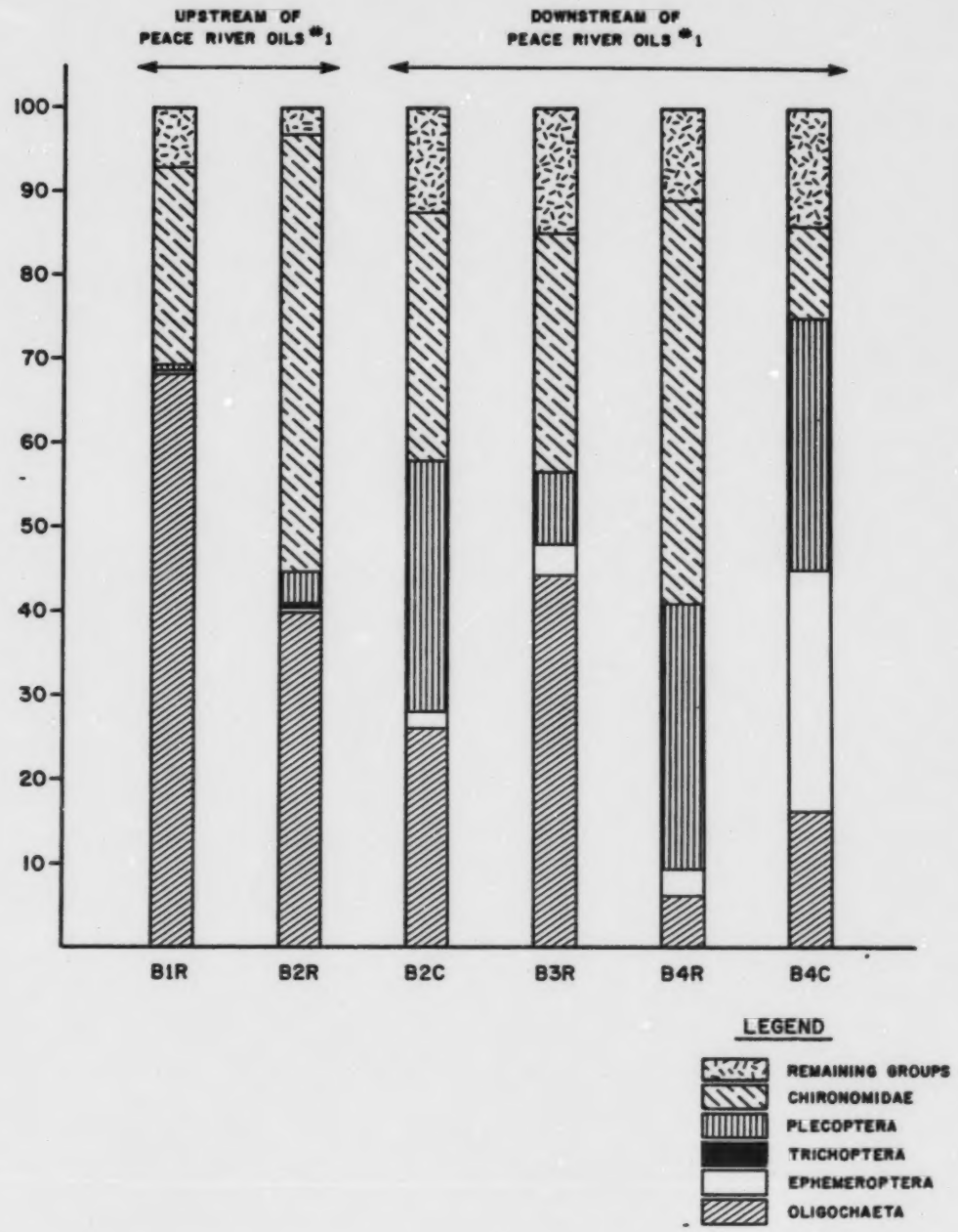

FIGURE 5 PEACE RIVER, OCTOBER 1988: PERCENT CONTRIBUTION OF MAJOR BENTHIC INVERTEBRATE GROUPS TO TOTAL NUMBERS.

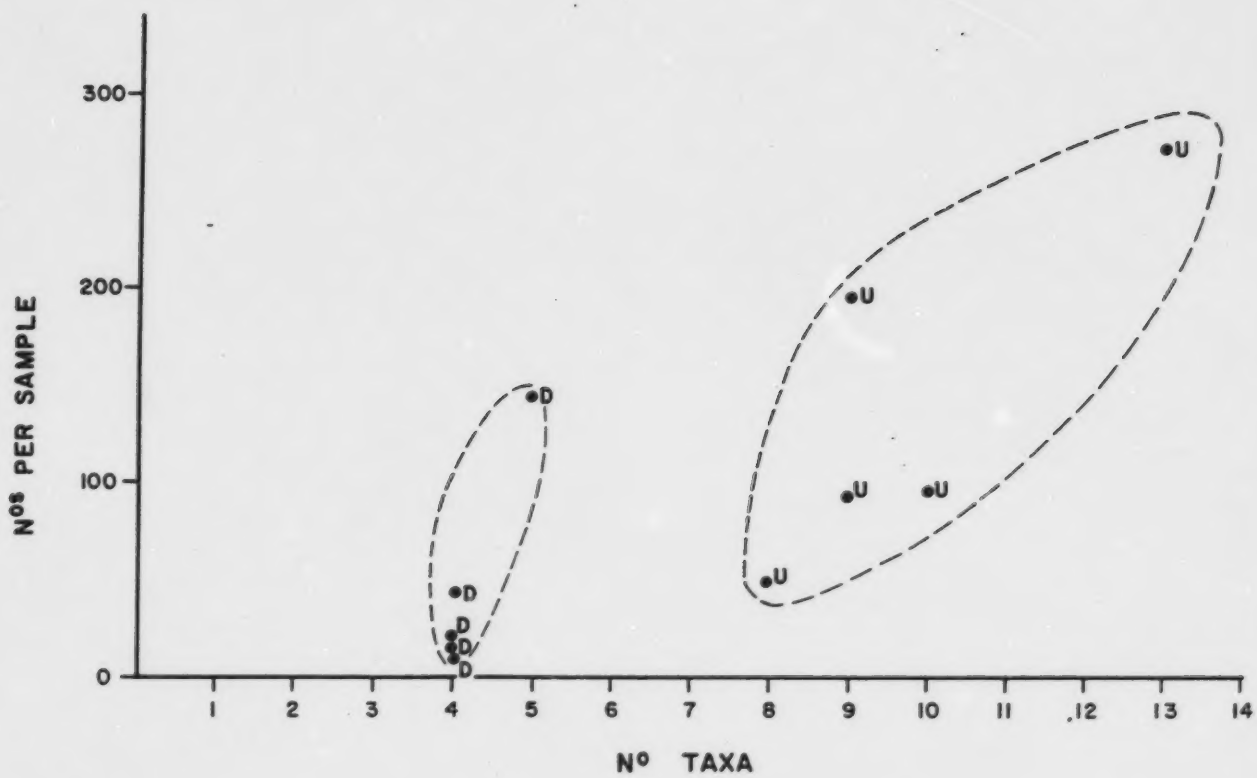

FIGURE 6 PEACE RIVER IN THE IMMEDIATE VICINITY OF PEACE RIVER OILS #1 WELL: ORDINATION OF THE NUMBER OF INVERTEBRATE TAXA AND THE NUMBER OF SPECIMENS COLLECTED 100m UPSTREAM (U) AND 100m DOWNSTREAM (D) OF THE WELL MAY 24, 1989.

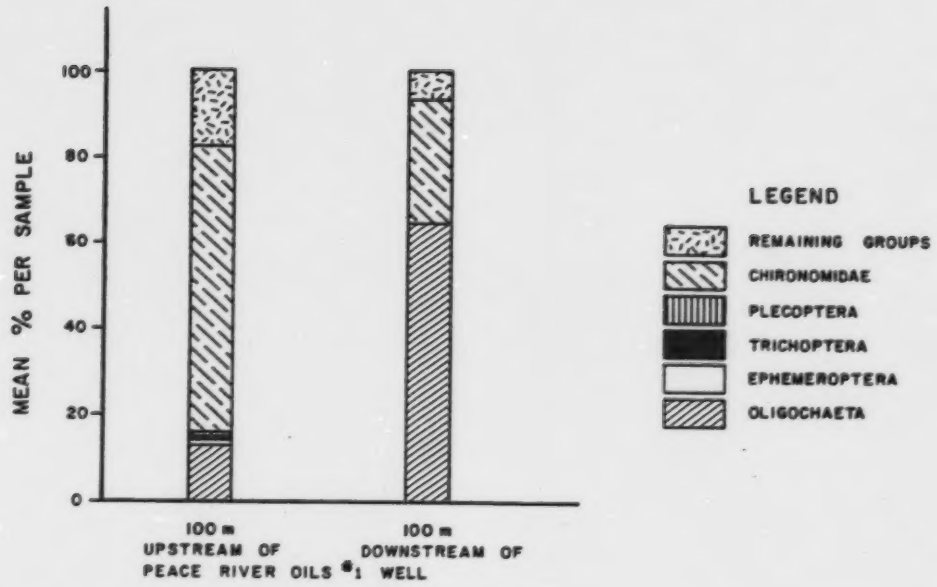

FIGURE 7 PEACE RIVER IN THE IMMEDIATE VICINITY OF PEACE RIVER OILS #1 WELL : PERCENT CONTRIBUTION OF MAJOR BENTHIC INVERTEBRATE GROUPS TO TOTAL NUMBERS MAY 24, 1989.

presence in soft riverine sediment is quite normal. However, these taxa are also known to be tolerant of a wide range of environmental conditions and they can survive under conditions which are unsuitable to most other organisms. The dominance of tubificids and chironomids in the samples collected 100 m below the well may be an indication that such unsuitable conditions exist below the well. Most samples collected 100 m above the well had higher numbers of tubificids and chironomids, but many other invertebrates were also present. These included Limoniinae (Tipulidae), Hydroptylidae (Trichoptera), Baetidae (Ephemeroptera), Perlodidae and Capniidae (Plecoptera), Cyclopoidae, and Pseudoscorpiones. Unlike the situation described for the synoptic survey sites (3.4.1) the sites sampled in the immediate vicinity of the well were quite similar and differences in habitat should not account for differences in zoobenthos.

4.0 SUMMARY AND CONCLUSIONS

1. In addition to very high sodium and chloride concentrations, the Peace River Oils #1 Well effluent contains several organic and inorganic constituents which exceed CCREM (1987) guidelines for the protection of aquatic life and irrigation of agricultural land. According to Microtox tests, the effluent is extremely toxic.

2. The oil well effluent appears to have only minor localized effects on the quality of the Peace River. A slight overall increase in chloride concentration of the river results from the inflow of well effluent. Biological effects, as manifested by the zoobenthos, appear localized as well.

3. High chloride levels, the presence of phenols, the similarity between hydrocarbons found in the domestic and in the oil well, and the results of Microtox tests suggest that the domestic well at Nixon's farm may be contaminated.

4. Topsoils and subsoils in the vicinity of the well are contaminated with sour smelling gas and salts. Crops are least productive in contaminated areas.

5. Intrusion of saltwater in deeper soil zones (i.e., 3 and 6 m) and in groundwater could not be shown. The well cannot be regarded as the cause for the alleged "sinkholes".

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APPENDICES

APPENDIX 1 Water Quality Parameters and Analytical Methods

Parameter	Container	Preservation	Analytical Code	Analytical Method Or Instrument
Field Analysis				
Temperature			02061F	Field meter
pH			10301F	Field meter
Conductance			02041F	Field meter
Oxygen, dissolved			08101F	Field meter
Lab Analysis				
pH	P	Cool to 4°C	10301L	Meter
Ca	P	Cool to 4°C	20110L	Automated atomic absorption
Mg	P	Cool to 4°C	12303L	Atomic absorption, direct aspiration
Na	P	Cool to 4°C	11103L	Flame photometer
K	P	Cool to 4°C	19103L	Flame photometry, internal standard
HCO_3			06201L	Calculated
Cl	P	Cool to 4°C	17203L	Colourimetry, ferric ammonium sulfate and mercuric thiocyanate
SO_4	P	Cool to 4°C	16306L	Colourimetry, $BaCl_2$ and methylthymol blue
SiO_2	P	Cool to 4°C	14102L	Heteropoly blue colourimetry
F	P	Cool to 4°C	09107L	Automated potentiometric method
Conductance	P	Cool to 4°C	02041L	Meter
Total dissolved solids			00205L	Calculated
T. hardness			10602L	Calculated, as $CaCO_3$
Total alkalinity	P	Cool to 4°C	10101L	Potentiometric titration
Total residue			10474L	Calculated
Filterable residue	P	Cool to 4°C	10453L	Gravimetric
Non filterable Residue	P	Cool to 4°C	10407L	Gravimetric (0.45 μm filter)
NO_2+NO_3-N	P	Cool to 4°C	07105L	Colourimetry on autoanalyzer
Nitrite-N	P	Cool to 4°C	07205L	Colourimetry on autoanalyzer
Ammonia-N	P	2ml 5% H_2SO_4	07562L	Colourimetric analysis
Total Phosphorous	P	2ml 5% H_2SO_4	15421L	Colourimetry on autoanalyzer
Total Kjeldahl Nitrogen	P	2ml 5% H_2SO_4	07021L	Colourimetry on autoanalyzer
T. Nitrogen, particulate	P		07906L	Thermal conductivity
Biochemical oxygen demand	G	Cool to 4°C	08202L	5 day, 20°C
Chemical oxygen demand	P	2ml 5% H_2SO_4	08304L	Semi-automated colourimetry
C, dissolved organic	P	Cool to 4°C	06107L	Colourimetry
C, dissolved inorganic	P	Cool to 4°C	06154L	Colourimetry
C, Total	P	Cool to 4°C	06905L	Thermal conductivity
Phenols	G	1:1 H_2SO_4	06537L	Automated 4-aminoantipyrine colourimetry

APPENDIX 1 Cont'd

Oil and Grease	G	1:1 H_2SO_4	06524L	Freon extraction and IR spectrophotometry
Fe (extr)	P	Cool to 4°C	26304L	Atomic absorption, direct aspiration
Cr +6 (diss.)	P	1:1 HNO_3	24101L	Colourimetric with diphenylcarbazide
Hg (total)	P	HNO_3-$K_2Cr_2O_7$	80015L	Flameless atomic absorption
Co (total)	P	1:1 HNO_3	27009L	Atomic emission spectrometry (ICAP)
Cu (total)	P	1:1 HNO_3	29009L	ICAP method
Ni (total)	P	1:1 HNO_3	28009L	ICAP method
Cd (total)	P	1:1 HNO_3	48009L	ICAP method
Pb (extr.)	P	1:1 HNO_3	82302L	Atomic absorption, solvent extraction
Zn (total)	P	1:1 HNO_3	30009L	ICAP method
Mn (total)	P	1:1 HNO_3	25003L	ICAP method
Cr (total)	P	1:1 HNO_3	24009L	ICAP method
Be (extr)	P	1:1 HNO_3	04304L	Atomic absorption, solvent extraction
V (total)	P	1:1 HNO_3	23009L	ICAP method
Mo (total)	P	1:1 HNO_3	42009L	ICAP method
Al (extr)	P	1:1 HNO_3	13306L	Atomic absorption, solvent extraction
Se (total)	P	1:1 HNO_3	34005L	Goulden and Brooksbank (1974) method
As (total)	P	1:1 HNO_3	33005L	Goulden and Brooksbank (1974)
Bo (total)	P	1:1 HNO_3	-	
Ba (total)	P	1:1 HNO_3	56001L	
Li (total)	P	1:1 HNO_3	03001L	
Sr (total)	P	1:1 HNO_3	38001L	

P - polyethylene container G- Glass container
Analytical codes and methods: see Environment Canada (1986), and Alberta Environment (1981).

APPENDIX 2 Priority Pollutant Analysis Methodology

D. Smillie
Alberta Environmental Centre, Chemistry Wing

The method employed for extractable priority pollutants in the MD&RS Section is based on the EPA Method 625 and covers the analysis of a number of organics that are partitioned into an organic solvent and are amenable to capillary gas chromatography/mass spectrometry (GC/MS). The method for purgeable priority pollutants is based on EPA Method 624 and deals with organics that are purged from water onto a trap, then desorbed and analyzed by capillary GC/MS.

The surface water is collected in the field directly into pretreated one litre amber sample bottles and stored in a refrigerator at 2-5°C until the time of analysis. The entire one litre volume of sample is serially extracted with methylene chloride at a pH greater than 11 and again at a pH less than 2 using a separatory funnel. The methylene chloride extracts are dried and concentrated, ready for GC/MS analysis.

Mass spectrometric/gas chromatographic analysis permit the separation and measurement of the organics in the extract. Qualitative screening is performed on target compounds using the relative retention time and relative abundances of three characteristic ions from the GC/MS data of the components of the extract. A full identification of organics screened in this manner is performed using full reference spectra. Quantitative analysis is performed using a multi-internal standards technique in which the integrated areas of characteristic ions are utilized in the calculation. Unknown compounds are identified based on comparison with library spectra. Quantification of these non-target compounds (those that are not listed as priority pollutants) is accomplished by comparison of response with an appropriate internal standard.

The method employed for volatile or purgeable priority pollutants is the purge-and-trap technique. A sample volume of 200 mL is purged with an inert gas, helium. A Tenax trap adsorbs the volatile organics purged out of solution. This is followed by thermal desorption of the volatiles on the trap onto a GC column, and subsequent mass spectral analysis. Qualitative and quantitative analysis are performed in the same fashion as for extractable priority pollutants.

APPENDIX 3 Organic priority pollutants included in the trace organic contaminant analysis by Alberta Environmental Centre, 1983.

I. Extractables
(detection limit 1 $\mu g \cdot L^{-1}$)

ACID GROUPS

Benzoic Acid
4-Chloro-m-cresol
2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
2,4-Dinitrophenol
Hexadecanoic acid
2-Nitrophenol
4-Nitrophenol
Pentachlorophenol
Phenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

BASE NEUTRAL GROUP

Acenaphthene
Acenaphthylene
Anthracene
Benz(a)anthracene
Benzo(k)fluoranthene
Benzo(ghi)perylene
Benzo(a)pyrene
Chrysene
Dibenzo(ah)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Perylene
Phenanthrene
Pyrene

Chloroorganics

Benzo(b)Fluoranthene
2-Chloronaphthalene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
1,2,4-Trichlorobenzene

Nitroaromatics

Isophorone
Benzidine
2,4-Dinitrotoluene
2,6-Dinitrotoluene
1,2-Diphenylhydrazine
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosodiphenylamine
N-Nitrosodi-n-propylamine

Halo Ethers

4-Bromophenyl phenyl ether
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether
4-Chlorophenyl phenyl ether

Phthalate Esters

Butylbenzyl phthalate
Dibutylphthalate
Diethylphthalate
Dimethylphthalate
Di-n-octylphthalate
Bis(2-ethylhexyl)phthalate

II. Volatiles (Purgeables)
detection limit 0.1 $\mu g \cdot L^{-1}$

Benzene
Bromochloromethane
Bromodichloromethane
Bromoform
Bromomethane
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethoxyethylene
Chloroform
Dibromochloromethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
trans-1,2-Dichloroethylene
trans-1,3-Dichloropropylene
Ethyl benzene
Methylene chloride
Styrene
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
Trichloroethylene
1,1,1-Trichloroethane
1,2,2-Trichloroethane
Trichlorofluoromethane
o-Xylene
m,Xylene
p-Xylene
Vinyl Chloride

APPENDIX 4

Peace River Oils #1 Well: Results of Toxicity Tests
and Chemical Analyses Conducted by the ERCB
in October 1985 and October 1986

Yellow
Edmonton

W32-1083

LOCATION: LSD 4 | SEC 31 | TWP 85 | RGE 20 W | M 5

SAMPLE LOCATION NAME: Peace River Oils No. 1

SAMPLED BY: V. Jones

REPRESENTING: ERCB

DATE SAMPLED: DAY 21 | MO 10 | YR 85

TREATMENT CO.:

PROBLEM: comparison check for chlorides

APPEARANCE AS RECEIVED: clear, small amount sediment. Very strong H_2S odor.

APPEARANCE OF FILTRATE:

IONS	mg/l	IONS	mg/l
F		Mg	
Cl	15,840	Ca	
NO_2		Na	11,500
Br		K	148.
NO_3		Ca + Mg	[illegible]
PO_4		NH_4	
SO_4	16		
HCO_3	3755		
CO_3			
OH		H_2S	
T.D.S.	30,330	Cr	
pH	6.9	Fe	

DATE 24 OCTOBER 1985

MICROTOX:

EC50(5): >100

EC50(15): >100

EC20(5): 11

EC20(15): 15

TROUT CHECK. dilutions

1:10 = 3 dead 66 hours
1:20 = 3 OK at 114 hours

This is too salty even for livestock - cattle, horses, swine and even sheep will be un-thrifty, fowl generally will sicken and die. It is also toxic for reasons other than salanity.

ERCB

W32-1086

Yellow
Peace River

LOCATION						SAMPLE LOCATION NAME	
LSD	SEC	TWP	RGE	W	M		
4	31	85	20	W	5	Peace River No 1	E.R.C.B.

SAMPLED BY	REPRESENTING	DATE SAMPLED			TREATMENT CO.:
		DAY	MO	YR	
Vern Jones	E.R.C.B.	21	10	86	

PROBLEM: Water flowing into Peace River. Comparison check for Chlorides. See W52-1085, W24-984, W43-684, W34-582. Complete analysis if possible. Report on well going to Board.

APPEARANCE AS RECEIVED

APPEARANCE OF FILTRATE:

IONS	mg/l	IONS	mg/l
[illegible]		Mg	52
Cl	17114	Ca	41
CO_3		Na	12,400
[illegible]		K	143
HCO_3		Ca + Mg	
[illegible]		NH_4	
[illegible]	23		
HCO_3	3984.		
[illegible]	0.		
OH	0	H_2S	
[illegible]	32030	[illegible]	
pH	6.0	Fe	

Conductivity: 47200 µs. cm
Turbidity: 6.0 N.T.U.

DATE October 28 1986

MICROTOX: EC 50(5):

EC 50(15):

EC 20(5):

EC 20(15):

TROUT CHECK: NO

Historical data for this well are as follows:

Lab No	Cl	T.D.S.
W34-582	17,809	31,340
W43-684	18,722	-
W24-984	16,970	31,830
W52-1085	15,340	30,330
W32-1086	17,114	32,030

[illegible]

APPENDIX 5

Benthic Invertebrate Monitoring Data
Collected in October 1988 Pertinent to the
Peace River Oils #1 Well Study

PEACE RIVER - (B1R) 4 KM U/S DAISHOWA PULPMILL 00AL07HA2100

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	96	41	70	76	39
Naididae	1446	868	587	585	399
Tubificidae	41	40	19	17	13
ARTHROPODA					
ARACHNOIDA					
ACARI	1	0	0	2	1
CRUSTACEA					
COPEPODA					
Cyclopoida	0	1	0	1	0
Calanoida	0	0	1	0	1
INSECTA					
DIPTERA					
Ceratopogonidae	1	0	0	0	3
Chironomidae					
Chironomidae pupae	0	0	16	4	0
Chironomini	244	37	104	168	44
Diamesinae	0	1	0	0	0
Orthocladiinae	78	24	102	158	20
Tanypodinae	5	7	20	10	0
Tanytarsini	119	24	165	154	28
Prodiamesinae	5	0	0	0	0
Empididae					
Hemerodromia	1	1	5	3	0
EPHEMEROPTERA					
Baetidae	2	1	1	2	3
Ephemerellidae	0	0	2	0	0
Ephemerella	0	0	3	4	3
Heptageniidae	2	0	2	2	0
Heptagenia	1	1	7	1	0
Rhithrogena	0	0	2	0	0
Stenonema	0	0	2	0	0
Ephemeroptera immatures	1	0	0	0	0
HEMIPTERA					
Corixidae	0	1	0	0	0
PLECOPTERA					
Capniidae	6	0	9	1	1
Perlodidae	2	1	0	0	0

Isogenoides	0	0	0	1	0
Isoperla	15	17	18	13	11
Taeniopterygidae	1	0	0	0	0
Oemopteryx	1	4	7	7	4
Plecoptera immature	0	0	0	0	1
TRICHOPTERA					
Brachycentridae					
Brachycentrus	1	1	0	0	0
Hydropsychidae	1	0	0	0	0
Hydroptilidae	0	0	0	0	1
COELENTERATA	1	1	1	3	1
NEMATODA	51	33	71	50	64

PEACE RIVER - (B1L) 3 KM U/S DAISHOWA PULPMILL 00AL07HA2150

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	128	29	48	42	47
Naididae	264	43	30	51	83
Tubificidae	72	18	9	2	6
ARTHROPODA					
ARACHNOIDA					
ACARI	1	0	1	2	2
CRUSTACEA					
COPEPODA					
Cyclopoida	0	1	2	0	1
Calanoida	2	1	8	5	3
INSECTA					
COLLEMBOLA	0	0	0	1	0
DIPTERA					
Ceratopogonidae	0	1	0	1	0
Chironomidae					
Chironomidae pupae	8	4	0	8	4
Chironomini	32	48	13	16	41
Diamesinae	8	0	0	0	0
Orthocladiinae	103	136	104	128	124
Tanypodinae	4	28	75	67	33
Tanytarsini	671	469	544	758	730
Prodiamesinae	0	8	2	12	17
Empididae					
Hemerodromia	0	2	4	2	3
Tipulidae	0	0	0	1	0
EPHEMEROPTERA					
Baetidae	1	1	0	0	0
Ephemerellidae					
Ephemerella	4	10	2	1	4
Heptageniidae	8	30	46	21	37
Heptagenia	12	17	6	11	0
Rhithrogena	0	9	3	8	2
HEMIPTERA					
Corixidae	19	4	4	5	7
PLECOPTERA					
Capniidae	7	11	15	10	8
Chloroperlidae	0	1	0	0	1

Perlodidae	23	103	75	45	57
Isogenoides	0	2	4	2	2
Isoperla	57	109	87	142	63
Taeniopterygidae					
Oemopteryx	4	41	19	42	7
Plecoptera immature	0	2	0	1	1
TRICHOPTERA					
Brachycentridae					
Brachycentrus	0	0	0	1	2
Hydropsychidae					
Cheumatopsyche	0	0	3	2	0
Hydropsyche	2	5	7	7	2
COELENTERATA	44	28	33	35	28
NEMATODA	46	62	59	61	33

PEACE RIVER - (B2R) 2 KM D/S DAISHOWA PULPMILL 00AL07HA2200

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	24	32	40	11	32
Naididae	696	318	671	74	932
Tubificidae	13	46	12	6	16
ARTHROPODA					
ARACHNOIDA					
ACARI	0	1	0	1	0
CRUSTACEA					
CLADOCERA					
Bosminidae					
Bosmina	0	0	0	4	0
COPEPODA					
Harpacticoida	3	0	1	0	0
Calanoida	1	2	1	3	0
INSECTA					
COLEOPTERA	0	0	0	0	1
DIPTERA					
Chironomidae					
Chironomidae pupae	4	4	4	12	0
Chironomini	231	111	611	135	593
Orthocladiinae	96	66	56	88	76
Tanypodinae	12	37	0	20	24
Tanytarsini	396	289	224	280	208
Prodiamesinae	0	0	0	8	0
Empididae					
Hemerodromia	1	1	1	4	1
Diptera adults	0	0	1	0	1
EPHEMEROPTERA					
Baetidae	4	-1	0	4	1
Baetis	0	0	0	0	1
Ephemerellidae					
Ephemerella	6	2	8	7	13
Heptageniidae	2	2	0	2	4
Heptagenia	2	0	0	0	0
Rhithrogena	0	0	0	0	1
Ephemeroptera immatures	0	0	0	1	0
HEMIPTERA					
Corixidae	4	0	2	2	3

PLECOPTERA					
Capniidae	5	5	0	6	9
Chloroperlidae	2	0	0	0	0
Plecoptera immature	0	1	0	0	1
Perlodidae	28	20	4	17	18
Isogenoides	1	0	1	1	0
Isoperla	80	26	10	26	63
Taeniopterygidae					
Oemopteryx	7	7	3	4	4
TRICHOPTERA					
Brachycentridae					
Brachycentrus	0	1	0	0	0
Hydropsychidae	0	2	0	2	2
Cheumatopsyche	5	9	0	13	2
Hydropsyche	6	14	1	27	5
TERRESTRIAL INSECTS	0	0	1	0	0
COELENTERATA	4	11	2	17	5
MOLLUSCA	0	0	1	0	2
NEMATODA	10	20	25	31	23
PLATYHELMINTHES					
TURBELLARIA	1	0	0	0	0
TARDIGRADA	1	0	0	0	0

PEACE RIVER - (B2L) 5 KM D/S DAISHOWA SITE 00AL07HA2600

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON. B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	49	65	81	81	61
Naididae	15	28	22	43	42
Tubificidae	3	8	3	0	1
ARTHROPODA					
ARACHNOIDA					
ACARI	1	3	2	2	0
CRUSTACEA					
CLADOCERA					
Bosminidae					
Bosmina	0	0	1	1	0
Chydoridae	0	0	0	0	1
COPEPODA					
Cyclopoida	4	4	3	2	2
Calanoida	4	1	4	6	1
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	3	1	0	3	1
Chironomini	18	7	11	23	20
Orthocladiinae	73	110	118	97	97
Tanypodinae	8	8	24	20	13
Tanytarsini	103	200	172	155	183
Prodiamesinae	0	1	0	0	0
Empididae					
Hemerodromia	2	1	0	2	3
Tipulidae	0	0	0	1	0
Diptera adults	1	0	0	0	0
EPHEMEROPTERA					
Baetidae	3	1	4	2	0
Ephemerellidae					
Ephemerella	7	6	9	8	10
Heptageniidae	4	12	29	27	13
Rhithrogena	2	6	11	13	22
HEMIPTERA					
Corixidae	0	0	0	0	1
PLECOPTERA					
Capniidae	4	3	16	7	11

Chloroperlidae	0	1	2	0	1
Perlodidae	77	193	268	262	257
Isogenoides	1	1	8	4	7
Isoperla	28	45	81	84	99
Taeniopterygidae					
Oemopteryx	22	55	77	47	65
Plecoptera immature	2	3	2	0	0
TRICHOPTERA					
Brachycentridae					
Brachycentrus	1	0	1	0	0
Hydropsychidae	1	2	5	0	3
Cheumatopsyche	2	2	1	0	0
Hydropsyche	1	4	4	8	7
COELENTERATA	5	9	34	18	13
NEMATODA	38	14	39	44	44
PLATYHELMINTHES					
TURBELLARIA	0	1	0	0	0

PEACE RIVER - (B2C) 7 KM DOWNSTREAM OF DAISHOWA PULPMILL 00AL07HA2620

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	80	2	34	46	32
Naididae	17	45	111	21	7
Tubificidae	0	7	0	0	0
ARTHROPODA					
ARACHNOIDA					
ACARI	2	0	1	0	1
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	0	0	0	0	1
Bosminidae					
Bosmina	0	1	0	1	0
COPEPODA					
Cyclopoida	2	2	2	5	3
Harpacticoida	0	1	0	0	0
Calanoida	2	4	1	4	4
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	3	1	0	0	0
Chironomini	22	6	11	13	13
Orthocladiinae	94	33	70	38	61
Tanypodinae	2	1	0	2	1
Tanytarsini	22	7	14	5	9
EPHEMEROPTERA					
Baetidae	2	0	0	2	1
Ephemerellidae					
Ephemerella	8	0	6	4	6
Heptageniidae	7	4	5	1	4
Heptagenia	1	0	0	0	0
Rhithrogena	0	2	0	1	1
PLECOPTERA					
Capniidae	5	0	0	3	4
Perlodidae	76	21	85	37	59
Isogenoides	1	0	0	0	2
Isoperla	15	9	12	9	12
Taeniopterygidae					

Oemopteryx	19	7	24	6	28
Plecoptera immature	1	0	0	0	1
TRICHOPTERA					
Hydropsychidae					
Hydropsyche	0	0	1	0	0
COELENTERATA	8	15	15	14	6
NEMATODA	24	9	12	18	13

PEACE RIVER - (B3L) 17 KM D/S DAISHOWA PULPMILL 00AL07HA2640

SAMPLER: NEILL CYLINDRE SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	120	24	55	41	86
Lumbriculidae	0	1	0	0	0
Naididae	39	1	32	10	10
ARTHROPODA					
ARACHNOIDA					
ACARI	8	2	3	1	2
CRUSTACEA					
CLADOCERA					
Bosminidae					
Bosmina	0	1	4	3	0
COPEPODA					
Cyclopoida	3	2	1	1	2
Harpacticoida	2	0	1	0	0
Calanoida	0	9	2	6	3
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	8	0	0	4	0
Chironomini	24	16	20	12	6
Orthocladiinae	140	92	104	96	24
Tanypodinae	21	9	16	28	2
Tanytarsini	497	300	404	490	67
Prodiamesinae	0	0	4	0	0
Empididae					
Hemerodromia	0	1	0	0	0
Diptera adults	1	0	0	0	0
EPHEMEROPTERA					
Baetidae	4	2	2	0	1
Ephemerellidae					
Ephemerella	3	2	4	3	0
Heptageniidae	35	31	55	56	24
Heptagenia	4	2	8	4	0
Rhithrogena	12	27	1	26	2
Stenonema	0	0	0	1	0
HEMIPTERA					
Corixidae	0	0	1	0	0
PLECOPTERA					

Capniidae	17	16	15	24	9
Chloroperlidae	0	0	0	1	1
Perlodidae	106	101	125	113	71
Isogenoides	0	0	1	2	0
Isoperla	102	86	69	74	57
Taeniopterygidae	6	0	2	0	0
Oemopteryx	41	21	12	36	20
Plecoptera immature	2	1	3	3	3
TRICHOPTERA					
Hydropsychidae	1	0	1	0	0
Cheumatopsyche	0	1	1	4	1
Hydropsyche	1	2	0	2	0
COELENTERATA	44	11	45	50	16
NEMATODA	51	16	22	23	35

PEACE RIVER - (B3R) 20 KM D/S DAISHOWA PULPMILL 00AL07HA2660

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	71	44	47	60	37
Naididae	159	39	11	53	28
Tubificidae	0	2	0	1	0
ARTHROPODA					
ARACHNOIDA					
ACARI	1	0	0	0	1
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	1	0	1	0	0
COPEPODA					
Cyclopoida	0	1	0	0	0
Calanoida	0	0	0	1	0
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	0	2	0	7	2
Chironomini	35	22	23	24	4
Orthocladiinae	32	28	32	32	15
Tanypodinae	1	2	2	1	1
Tanytarsini	28	28	19	31	16
Empididae					
Hemerodromia	1	1	0	0	0
EPHEMEROPTERA					
Baetidae	0	1	0	0	0
Ephemerellidae					
Ephemerella	0	0	1	0	0
Heptageniidae	5	2	6	1	0
Heptagenia	0	1	1	1	1
Rhithrogena	1	1	1	0	1
Tricorythidae					
Tricorythodes	0	0	1	0	0
HEMIPTERA					
Corixidae	0	1	0	0	0
PLECOPTERA					
Capniidae	9	11	13	6	5
Perlodidae	2	3	3	4	4

Isoperla	1	4	2	5	1
Taeniopterygidae					
Oemopteryx	2	5	2	4	0
Plecoptera immature	1	2	0	0	0
COELENTERATA	23	22	15	14	9
NEMATODA	26	12	18	20	17

PEACE RIVER - (B4R) 32 KM D/S DAISHOWA PULPMILL 00AL07HA2680

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	48	46	24	17	23
Naididae	4	11	11	0	10
ARTHROPODA					
ARACHNOIDA					
ACARI	6	4	13	1	2
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	0	1	0	0	0
Bosminidae					
Bosmina	0	0	1	0	0
COPEPODA					
Cyclopoida	5	9	1	2	4
Calanoida	4	0	5	11	9
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	4	0	8	2	5
Chironomini	122	22	45	32	26
Orthocladiinae	464	62	365	112	136
Tanypodinae	0	7	8	3	6
Tanytarsini	40	2	56	20	18
Empididae					
Hemerodromia	0	0	0	2	0
Tipulidae	1	0	0	0	1
EPHEMEROPTERA					
Baetidae	5	0	11	1	1
Ephemerellidae					
Ephemerella	2	2	6	6	9
Heptageniidae	9	4	15	6	7
Heptagenia	0	0	1	0	0
Rhithrogena	1	0	6	1	2
PLECOPTERA					
Capniidae	3	1	3	4	5
Chloroperlidae	0	0	2	0	0
Plecoptera immatures	3	3	6	3	4
Perlodidae	61	34	139	52	87

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PEACE RIVER - (B4R) 32 KM D/S DAISHOWA PULPMILL 00AL07HA2680

Isogenoides	3	6	6	1	6
Isoperla	27	22	74	30	32
Taeniopterygidae					
Oemopteryx	61	49	105	65	98
TRICHOPTERA					
Hydropsychidae					
Hydropsyche	1	0	0	0	2
Cheumatopsyche	1	0	0	0	1
COELENTERATA	6	9	18	0	22
NEMATODA	41	55	21	48	25
PLATYHELMINTHES					
TURBELLARIA	0	0	3	0	1

PEACE RIVER - (B4C) 33 KM D/S DAISHOWA PULPMILL 00AL07HA2700

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	29	19	52	12	43
Naididae	5	0	6	4	14
ARTHROPODA					
ARACHNOIDA					
ACARI	0	1	0	0	0
CRUSTACEA					
CLADOCERA					
Bosminidae					
Bosmina	0	1	0	1	0
COPEPODA					
Cyclopoida	1	1	1	6	2
Harpacticoida	1	0	0	1	0
Calanoida	2	7	4	10	6
INSECTA					
COLEOPTERA					
Curculionidae	0	1	0	0	0
DIPTERA					
Chironomidae					
Chironomini	15	9	13	10	14
Orthocladiinae	10	5	9	13	16
Tanypodinae	1	0	0	0	0
Tanytarsini	5	2	1	2	3
Empididae					
Hemerodromia	0	1	0	0	0
EPHEMEROPTERA					
Baetidae	1	1	0	2	0
Heptageniidae	14	17	22	17	25
Rhithrogena	39	23	52	42	42
Ephemerellidae					
Ephemerella	0	1	1	0	1
PLECOPTERA					
Capniidae	0	2	2	1	1
Chloroperlidae	0	3	0	0	0
Plecoptera immature	0	0	2	0	0
Perlodidae	38	18	58	31	47
Isogenoides	4	6	2	0	1
Isoperla	6	7	7	7	22

Taeniopterygidae					
Oemopteryx	14	12	15	11	19
TRICHOPTERA					
Hydropsychidae	0	0	0	1	0
Arctopsyche	0	1	0	0	0
COELENTERATA	24	7	28	15	14
NEMATODA	8	2	0	0	1
PLATYHELMINTHES					
TURBELLARIA	0	0	0	0	2

PEACE RIVER - (B4L) 35 KM D/S DAISHOWA PULPMILL 00AL07HA2800

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	68	59	42	47	63
Naididae	54	60	34	35	44
Tubificidae	4	6	0	2	0
ARTHROPODA					
ARACHNOIDA					
ACARI	2	1	2	2	2
CRUSTACEA					
COPEPODA					
Cyclopoida	0	2	1	0	0
Harpacticoida	1	6	3	4	2
Calanoida	1	0	1	0	0
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	8	0	0	4	0
Chironomini	16	4	5	12	908
Orthocladiinae	84	110	108	88	73
Tanypodinae	0	4	16	12	21
Tanytarsini	1191	1163	920	782	8
Empididae					
Chelifera	1	2	0	0	0
Hemerodromia	17	9	13	10	16
EPHEMEROPTERA					
Baetidae	2	3	1	8	10
Ephemerellidae					
Ephemerella	0	0	1	3	2
Heptageniidae	70	76	47	45	64
Heptagenia	0	0	7	2	5
Rhithrogena	14	13	9	23	7
Leptophlebiidae					
Paraleptophlebia	1	0	0	0	0
HEMIPTERA					
Corixidae	0	0	1	0	0
PLECOPTERA					
Capniidae	7	1	2	3	2
Perlodidae	70	100	80	102	42
Isoperla	18	32	40	59	77

Taeniopterygidae	11	0	0	0	0
Oemopteryx	31	80	65	112	85
Plecoptera immature	2	1	0	2	3
TRICHOPTERA					
Brachycentridae					
Brachycentrus	0	0	1	0	0
Hydropsychidae	0	2	0	5	0
Cheumatopsyche	0	1	0	0	0
Hydropsyche	0	0	0	2	0
COELENTERATA	33	36	34	35	32
NEMATODA	25	26	30	21	26

PEACE RIVER - (B1L) 3 KM U/S DAISHOWA PULPMILL 00AL07HA2150

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY: A.M. ANDERSON AND W.J. ANDERSON
SORTING BY: M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS: W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	4	10	0	5	6
Naididae	25	1	0	9	9
Tubificidae	3	8	0	5	1
ARTHROPODA					
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	1	4	4	2	5
COPEPODA					
Cyclopoida	0	0	1	1	1
Calanoida	7	4	13	9	4
INSECTA					
DIPTERA					
Chironomidae					
Chironomini	13	11	3	4	6
Orthocladiinae	1	2	0	12	
Tanypodinae	1	0	0	2	1
Tanytarsini	0	1	1	0	1
Prodiamesinae	0	1	1	1	0
EPHEMEROPTERA					
Baetidae					
Baetis	0	1	0	0	0
Ephemerellidae					
Ephemerella	0	0	1	0	0
Heptageniidae	0	0	0	1	0
PLECOPTERA					
Perlodidae					
Isogenoides	0	1	0	0	0
TRICHOPTERA					
Brachycentridae					
Brachycentrus	0	0	0	0	1
Trichoptera immatures	0	0	0	0	2
NEMATODA	4	2	4	4	7

PEACE RIVER - (B1R) 4 KM U/S DAISHOWA PULPMILL 00AL07HA2100

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	0	0	1	0	0
Naididae	1	10	1	3	8
Tubificidae	77	110	46	58	62
ARTHROPODA					
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	1	0	0	1	0
COPEPODA					
Cyclopoida	1	0	2	0	0
Calanoida	0	0	3	1	1
INSECTA					
DIPTERA					
Ceratopogonidae	0	0	0	0	1
Chironomidae					
Chironomidae pupae	1	0	0	0	1
Chironomini	7	2	9	11	8
Orthocladiinae	4	3	1	1	2
Tanypodinae	0	1	0	0	0
Tanytarsini	0	1	3	4	4
EPHEMEROPTERA					
Baetidae	0	0	0	4	0
Caenidae					
Caenis	0	0	0	1	0
Tricorythidae					
Tricorythodes	0	0	0	0	1
TRICHOPTERA					
Hydropsychidae	1	0	0	0	0
TERRESTRIAL INSECTS	0	0	0	1	0
COELENTERATA	13	13	12	12	16
NEMATODA	27	20	10	12	14

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	1	1	2	3	2
Naididae	5	3	5	4	3
Tubificidae	12	6	5	22	21
ARTHROPODA					
ARACHNOIDA					
ACARI	0	1	1	2	0
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	4	1	1	7	1
COPEPODA					
Cyclopoida	3	5	2	7	1
Calanoida	0	0	3	3	4
INSECTA					
DIPTERA					
Ceratopogonidae	0	0	0	2	0
Chironomidae					
Chironomidae pupae	1	3	3	3	2
Chironomini	7	4	24	34	8
Orthocladiinae	11	4	8	10	2
Tanypodinae	2	2	5	2	2
Tanytarsini	35	47	63	41	25
Empididae					
Hemerodromia	0	0	1	1	0
EPHEMEROPTERA					
Baetidae	0	0	3	1	0
Ephemerellidae					
Ephemerella	0	1	2	1	0
Heptageniidae	9	6	11	12	3
Heptagenia	2	0	14	8	2
Siphlonuridae					
Ameletus	3	1	1	1	0
PLECOPTERA					
Capniidae	0	1	0	3	1
Chloroperlidae	1	0	0	1	0
Perlidae					
Claassenia sabulosa	1	0	0	0	0
Perlodidae	6	0	15	13	5

Isogenoides	0	0	0	1	2
Isoperla	0	0	1	0	0
TRICHOPTERA					
Hydropsychidae	15	5	5	11	4
Hydropsyche	13	5	14	14	6
Trichoptera immatures	0	0	0	1	0
COELENTERATA	68	40	117	123	39
NEMATODA	5	4	2	19	9

PEACE RIVER - (B2L) 5 KM D/S DAISHOWA SITE 00AL07HA2600

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J.ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE		
ANNELIDA			
OLIGOCHAETA			
HAPLOTAXIDA			
Enchytraeidae	6	2	47
Naididae	3	12	4
Tubificidae	128	34	0
ARTHROPODA			
CRUSTACEA			
CLADOCERA			
Daphniidae			
Daphnia	3	5	2
COPEPODA			
Cyclopoida	2	0	1
Calanoida	10	7	7
INSECTA			
DIPTERA			
Ceratopogonidae	0	0	1
Chironomidae			
Chironomidae pupae	2	0	0
Chironomini	4	45	7
Orthocladiinae	0	1	0
Tanypodinae	1	2	0
Tanytarsini	0	0	1
Diptera adults	0	0	1
EPHEMEROPTERA			
Ephemerellidae			
Ephemerella	0	0	1
Heptageniidae			
Heptagenia	1	3	4
PLECOPTERA			
Perlodidae	1	0	5
Isogenoides	0	0	2
Chloroperlidae			
Suwallia complex	1	0	2
TRICHOPTERA			
Hydropsychidae	1	2	0
Trichoptera immatures	1	0	0
COELENTERATA	152	228	172

NEMATODA	7	8	9

PEACE RIVER - (B2C) 7 KM DOWNSTREAM OF DAISHOWA PULPMILL 00AL07HA2620

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	7	10	12	19	19
Naididae	1	0	0	2	0
ARTHROPODA					
ARACHNOIDA					
ACARI	0	0	2	0	0
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	45	5	48	29	33
COPEPODA					
Cyclopoida	9	6	5	11	7
Calanoida	41	47	46	28	31
OSTRACODA	1	0	0	0	0
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	6	5	3	3	7
Chironomini	6	12	9	8	7
Orthocladiinae	1	5	1	1	1
Tanytarsini	7	10	14	13	21
Tipulidae	0	0	1	0	0
EPHEMEROPTERA					
Baetidae	2	1	0	0	0
Heptageniidae	7	16	5	12	4
Heptagenia	0	0	0	1	0
Rhithrogena	2	3	3	1	0
Tricorythidae					
Tricorythodes	0	0	0	0	1
PLECOPTERA					
Chloroperlidae	0	1	0	0	1
Perlidae					
Claassenia sabulosa	0	1	0	0	0
Perlodidae	13	22	5	13	6
Isogenoides	3	2	1	3	1
Isoperla	0	1	0	0	0
Taeniopterygidae	0	1	1	0	0
TRICHOPTERA					
Brachycentridae					

Brachycentrus	1	1	2	1	1
Hydropsychidae	0	1	0	2	0
Hydropsyche	2	2	0	0	0
TERRESTRIAL INSECTS	0	0	1	0	0
COELENTERATA	123	111	88	97	57
NEMATODA	2	3	2	2	2

PEACE RIVER - (B3L) 17 KM D/S DAISHOWA PULPMILL 00AL07HA2640

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	25	20	82	52	45
Naididae	1	1	2	0	1
ARTHROPODA					
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	1	3	1	0	3
COPEPODA					
Cyclopoida	3	1	0	4	1
Harpacticoida	2	1	30	2	1
Calanoida	9	3	1	3	0
OSTRACODA	2	0	1	2	0
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	2	3	2	5	7
Chironomini	9	6	27	6	4
Orthocladiinae	0	4	6	3	7
Tanypodinae	1	0	1	0	1
Tanytarsini	14	12	17	13	16
Empididae					
Hemerodromia	1	1	0	0	0
EPHEMEROPTERA					
Baetidae					
Baetis	0	0	1	0	0
Ephemerellidae	1	0	0	0	0
Ephemerella	0	0	0	0	1
Heptageniidae	0	1	1	1	2
Heptagenia	0	0	1	0	0
PLECOPTERA					
Perlodidae	21	21	22	12	9
Isogenoides	1	1	1	0	4
Isoperla	0	0	2	0	0
Plecoptera immature	0	0	0	1	0
TRICHOPTERA					
Brachycentridae					
Brachycentrus	1	0	0	1	0
Hydropsychidae	4	3	8	2	1

Cheumatopsyche	0	0	2	0	0
Hydropsyche	9	8	10	6	0
COELENTERATA	57	73	158	82	115
NEMATODA	0	1	2	3	2

PEACE RIVER - (B3R) 20 KM D/S DAISHOWA PULPMILL 00AL07HA2660

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	10	5	18	4	15
Naididae	2	1	10	5	1
Tubificidae	0	1	4	1	1
ARTHROPODA					
ARACHNOIDA					
ACARI	0	0	2	2	0
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	0	0	1	1	2
COPEPODA					
Calanoida	0	0	3	5	9
INSECTA					
DIPTERA					
Ceratopogonidae	0	0	1	0	0
Chironomidae					
Chironomidae pupae	5	0	4	0	3
Chironomini	2	11	14	3	2
Orthocladiinae	2	3	11	2	1
Tanypodinae	0	0	1	0	1
Tanytarsini	29	34	28	18	33
EPHEMEROPTERA					
Baetidae	0	1	4	1	2
Baetis	0	3	1	0	2
Heptageniidae	5	16	12	11	9
Cinygmula	0	2	0	0	0
Heptagenia	0	0	1	1	0
Rhithrogena	11	34	27	15	11
PLECOPTERA					
Capniidae	0	0	1	0	0
Chloroperlidae	1	1	0	0	0
Nemouridae					
Malenka	0	0	0	1	0
Perlidae	0	1	0	1	0
Claassenia sabulosa	0	0	1	0	0
Perlodidae	23	41	76	22	20
Isogenoides	1	2	6	3	3

Isoperla	0	1	2	1	1
Taeniopterygidae	1	0	1	0	0
TRICHOPTERA					
Brachycentridae					
Brachycentrus	0	2	0	0	0
Glossosomatidae					
Glossosoma	0	0	0	1	1
Hydropsychidae	2	3	19	1	3
Cheumatopsyche	0	0	1	0	0
Hydropsyche	13	15	26	4	11
Hydroptilidae					
Hydroptila	0	0	1	0	0
COELENTERATA	32	81	75	59	43
NEMATODA	0	1	9	3	5

PEACE RIVER - (B4R) 32 KM D/S DAISHOWA PULPMILL 00AL07HA2680

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	7	25	3	15	18
Naididae	0	2	0	1	0
ARTHROPODA					
ARACHNOIDA					
ACARI	0	1	0	1	0
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	1	2	3	1	4
COPEPODA					
Cyclopoida	1	6	1	2	1
Calanoida	5	11	9	10	7
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	1	10	9	14	33
Chironomini	4	10	6	7	6
Orthocladiinae	1	8	4	5	2
Tanypodinae	0	1	0	0	0
Tanytarsini	3	6	12	8	16
Simuliidae	0	0	0	1	0
Tipulidae	1	0	0	0	0
EPHEMEROPTERA					
Baetidae	0	0	3	0	1
Baetis	0	1	0	0	0
Ephemerellidae	0	0	1	0	1
Ephemerella	0	1	0	0	0
Heptageniidae	1	10	7	6	1
Rhithrogena	0	7	7	7	3
PLECOPTERA					
Perlidae	0	1	0	0	0
Perlodidae	4	23	8	11	15
Isogenoides	1	2	3	2	2
Isoperla	1	3	0	0	1
Taeniopterygidae	0	0	0	0	1
TRICHOPTERA					
Brachycentridae					
Brachycentrus	0	2	1	0	0

Glossosomatidae					
Glossosoma	0	1	0	0	0
Hydropsychidae	0	0	1	0	0
Hydropsyche	0	4	2	0	3
COELENTERATA	61	116	65	80	56
NEMATODA	0	1	2	7	1

PEACE RIVER - (B4C) 33 KM D/S DAISHOWA PULPMILL 00AL07HA2700

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	8	14	27	15	21
Naididae	1	0	0	1	2
ARTHROPODA					
ARACHNOIDA					
ACARI	1	0	0	0	0
CRUSTACEA					
CLADOCERA					
Daphniidae					
Daphnia	0	1	2	6	3
COPEPODA					
Cyclopoida	0	2	1	0	2
Calanoida	2	4	0	3	4
INSECTA					
DIPTERA					
Chironomidae					
Chironomidae pupae	4	8	13	7	2
Chironomini	23	11	15	11	12
Orthocladiinae	3	4	8	2	7
Tanytarsini	0	2	0	0	3
Tipulidae	1	1	2	0	2
Diptera adults	1	0	0	0	0
EPHEMEROPTERA					
Baetidae	0	1	2	0	0
Ephemerellidae					
Ephemerella	0	0	0	1	0
Heptageniidae	1	3	1	1	1
Rhithrogena	1	0	1	0	0
HEMIPTERA	1	0	0	0	1
PLECOPTERA					
Brachycentridae					
Brachycentrus	0	2	0	0	0
Perlodidae	3	2	0	1	2
Isogenoides	0	1	2	2	0
Isoperla	0	0	0	1	1
Taeniopterygidae	0	0	1	0	1
COELENTERATA	33	37	38	34	43

NEMATODA	0	0	1	1	0

PEACE RIVER - (B4L) 35 KM D/S DAISHOWA PULPMILL 00AL07HA2800

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

	REPLICATE				
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Enchytraeidae	21	16	11	6	4
Naididae	7	9	16	14	15
Tubificidae	58	53	5	6	4
ARTHROPODA					
ARACHNOIDA					
ACARI	3	0	0	0	0
CRUSTACEA					
COPEPODA					
Calanoida	2	1	1	3	3
INSECTA					
DIPTERA					
Ceratopogonidae	0	0	0	0	1
Chironomidae					
Chironomidae pupae	1	3	1	1	2
Chironomini	14	27	29	21	7
Orthocladiinae	3	7	3	0	0
Tanypodinae	2	5	1	1	1
Tanytarsini	2	3	0	2	1
Prodiamesinae	2	3	0	1	1
Tipulidae	0	1	0	0	0
Diptera adults	22	6	1	5	4
EPHEMEROPTERA					
Baetidae	0	0	0	0	1
Ephemerellidae	1	0	0	0	0
Ephemerella	1	0	0	1	0
Heptageniidae	3	0	0	2	2
HEMIPTERA	0	4	0	0	1
Saldidae	2	0	0	0	0
PLECOPTERA					
Chloroperlidae					
Suwallia complex	0	0	0	1	0
Perlodidae	12	9	0	0	2
Isogenoides	2	1	0	0	0
TRICHOPTERA					
Hydropsychidae	17	21	0	3	4
Hydropsyche	0	1	0	0	0
TERRESTRIAL INSECTS	0	0	0	1	1

COELENTERATA	225	438	94	14	137
NEMATODA	6	5	1	4	10

APPENDIX 6

Benthic Invertebrate Data
Collected in the Immediate Vicinity of
Peace River Oils #1 Well in May 1989

ENVIRONMENTAL ASSESSMENT DIVISION MAY 24, 1989

PEACE RIVER - 100 mm Upstream of Peace River Oils #1

SAMPLER: Ekman dredge (22.5 x 22.5 cm^2)
FINEST MESH SIZE: 0.400 mm
COLLECTIONS BY: B. Jackson and J. Willis
COUNTS AND IDENTIFICATIONS BY: R. Casey

ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
NAIDIDAE	2	5	0	2	1
TUBIFICIDAE	28	10	23	15	11
ARTHROPODA					
CRUSTACEA					
COPEPODA					
CYCLOPOIDA	0	0	2	0	0
INSECTA					
COLLEMBOLA	1	4	2	0	0
DIPTERA					
CERATOPOGONIDAE	0	1	2	4	8
CHIRONOMIDAE					
ORTHOCLADIINAE	6	230	30	158	16
TANYPODINAE	16	9	2	9	3
CHIRONOMINAE	10	2	0	0	0
PUPAE	1	2	3	0	2
TIPULIDAE					
LIMONIINAE	0	0	1	1	0
EPHEMEROPTERA	0	0	0	0	1
BAETIDAE	2	2	0	0	0
PLECOPTERA	1	1	0	0	0
PERLODIDAE	0	0	0	1	0
CAPNIIDAE	0	1	0	0	0
TRICHOPTERA					
HYDROPTILIDAE	0	0	0	1	0
ARACHNOIDA					
PSEUDOSCORPIONES	0	1	0	0	0
NEMATODA	27	8	32	1	13

ENVIRONMENTAL ASSESSMENT DIVISION MAY 24, 1989

PEACE RIVER - 100 mm Downstream of Peace River Oils #1

SAMPLER: Ekman dredge (22.5 x 22.5 cm^2)
FINEST MESH SIZE: 0.400 mm
COLLECTIONS BY: B. Jackson and J. Willis
COUNTS AND IDENTIFICATIONS BY: R. Casey

ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
NAIDIDAE	1	0	0	0	1
TUBIFICIDAE	19	3	3	3	120
ARTHROPODA					
DIPTERA					
CERATOPOGONIDAE	0	3	2	3	1
CHIRONOMIDAE					
ORTHOCLADIINAE	24	4	7	11	18
TANYPODINAE	0	0	1	0	0
PUPAE	1	0	0	0	0
NEMATODA	0	1	0	0	3

APPENDIX 7

Hydrogen Sulphide Monitoring in the Vicinity of the Peace River Oils #1 Well

Dave: John T. agree to help AMA when this comes in.

ERCB

Inter-Office Memorandum

FROM: M. Miller, Environment Protection — 5 September 1989

TO: B. Olson, Grande Prairie Area Office

cc: L. Melnychyn, E.P.
E. J. Morin, B&A
J. R. Nichol, D&P
B. Kemper, A.Env.

ERCB MOBILE AIR MONITORING REPORT
PEACE RIVER OILS NO. 1 WELL
25 & 26 JULY 1989

The attached report summarizes the mobile air monitoring conducted at the Peace River Oils No. 1 Well on the 25 and 26 July 1989, by the ERCB's mobile air monitoring vehicle.

The readings are broken down into houly averages where possible and also peak concentrations for each averaging period. The peak concentrations that appear with a > symbol indicate that the response was beyond the scale of the analyser in use at the time.

The one-hour average maximum permissible hydrogen sulphide concentration is 0.01 ppm.

If you have any questions regarding this report, please call me at 297-3186.

MM/js

Attachments

RECEIVED
SEP 7 1989
Ans'd .....

ERCB MOBILE AIR MONITORING REPORT

AREA OFFICE: Grande Prairie

MONITOR OPERATOR: Mark Miller

DATE: 25 July 1989

AREAS MONITORED: Peace River Oils No. 1 Well

WEATHER CONDITIONS: '20^{0}C, Clear skies, southwest wind at approximately 5 km/h at 10:00 hrs.

Start/Finish Time	Monitoring Position	Gas Type	Peak Concentration	Average Concentration	Comments
10:40 hrs to 11:00 hrs	Northeast of flare approximately 30 m on edge of field.	H_2S	> 0.25 ppm	0.178 ppm	
11:00 hrs to 12:00 hrs	Northeast of flare approximately 30 m on edge of field.	H_2S	> 0.50 ppm	0.223 ppm	Change monitoring range on analyser from 0-0.25 ppm to 0-0.5 ppm at 11:00 hrs.
12:00 hrs to 13:00 hrs	North of flare approximately 30 m on edge of field.	H_2S	0.30 ppm	0.023 ppm	Wind shift to SSE at 12:00 hrs. Could not get directly in the gas plume as it was over the riverbank.
13:00 hrs to 14:00 hrs	North of flare approximately 30 m on edge of ffeld.	H_2S	0.32 ppm	0.056 ppm	
14:00 hrs to 15:00 hrs	North of flare approximately 30 m on edge of field.	H_2S	0.066 ppm	0.045 ppm	
15:00 hrs to 16:00 hrs	North of flare approximately 30 m on edge of field.	H_2S	> 0.50 ppm	0.074 ppm	Wind shifted to north at 15:30 hrs. Monitoring truck positioned approximately 30 m south of flare at 15:30 hrs.

ERCB MOBILE AIR MONITORING REPORT

AREA OFFICE: Grande Prairie

MONITOR OPERATOR: Mark Miller

DATE: 26 July 1989

AREAS MONITORED: Peace River Oils No. 1 Well

WEATHER CONDITIONS: 26^0C, Clear skies, west wind at approximately 5 km/h at 09:00 hrs.

Start/Finish Time	Monitoring Position	Gas Type	Peak Concentration	Average Concentration	Comments
09:30 hrs to 10:00 hrs	East of flare approximately 60 m on edge of field.	H_2S	0.235 ppm	0.108 ppm	
10:00 hrs to 11:00 hrs	East of flare approximately 60 m on edge of field.	H_2S	0.385 ppm	0.109 ppm	
11:00 hrs to 12:00 hrs	East of flare approximately 60 m on edge of field.	H_2S	0.282 ppm	0.110 ppm	
12:00 hrs to 12:15 hrs	East of flare approximately 60 m on edge of field.	H_2S	0.34 ppm	0.125 ppm	
12:15 hrs to 13:00 hrs	East of well approximately 300 m along east side of farm field.	H_2S	0.005 ppm	0.004 ppm	

APPENDIX 8

Results of Groundwater Monitoring

Alberta

MEMORANDUM

ENVIRONMENT WATER RESOURCES MANAGEMENT SERVICES

FROM E. Lorberg, P. Geol.
Hydrogeology Branch
Technical Services Division

OUR FILE REFERENCE 55.3.1.

YOUR FILE REFERENCE

TO D. Trew, Section Head
Water Quality Assessment
Environmental Quality Monitoring Branch

DATE September 28, 1989

TELEPHONE

SUBJECT Peace River Oils No. 1 Well

Following the meeting of September 20, 1989, the attached summary is transmitted for your consideration. In the absence of field data that could be produced through a comprehensive drilling and testing program I feel not entirely assured of the conclusion presented, although alternative options appear less realistic.

E. Lorberg, P. Geol.
Hydrogeology Branch
Technical Services Division

EL/sn

attach.

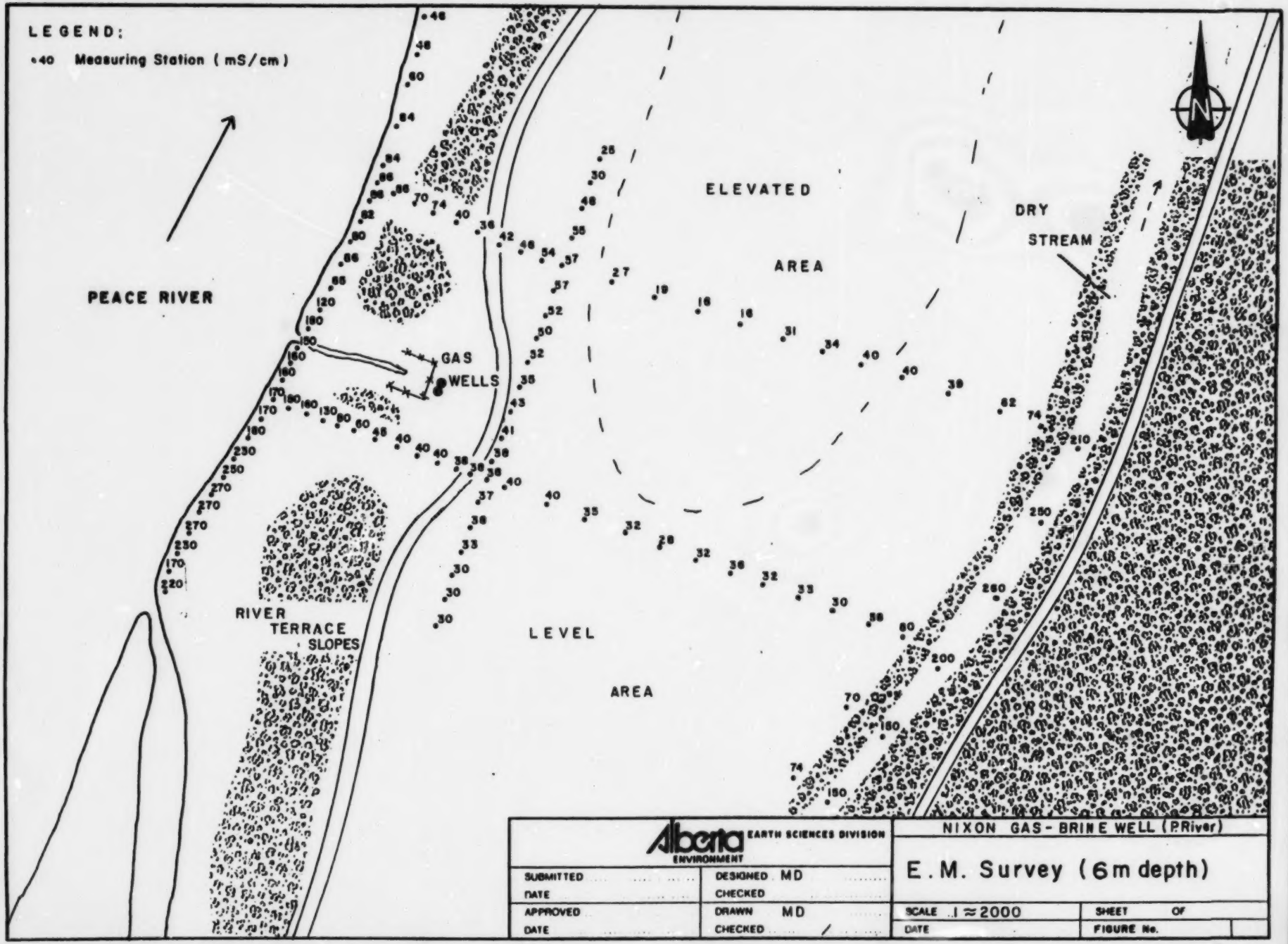
GROUNDWATER

Alleged saltwater contamination of soil and groundwater and the development of 'sinkholes' was investigated in the vicinity of the Peace River Oils No. 1 Well in July, 1989.

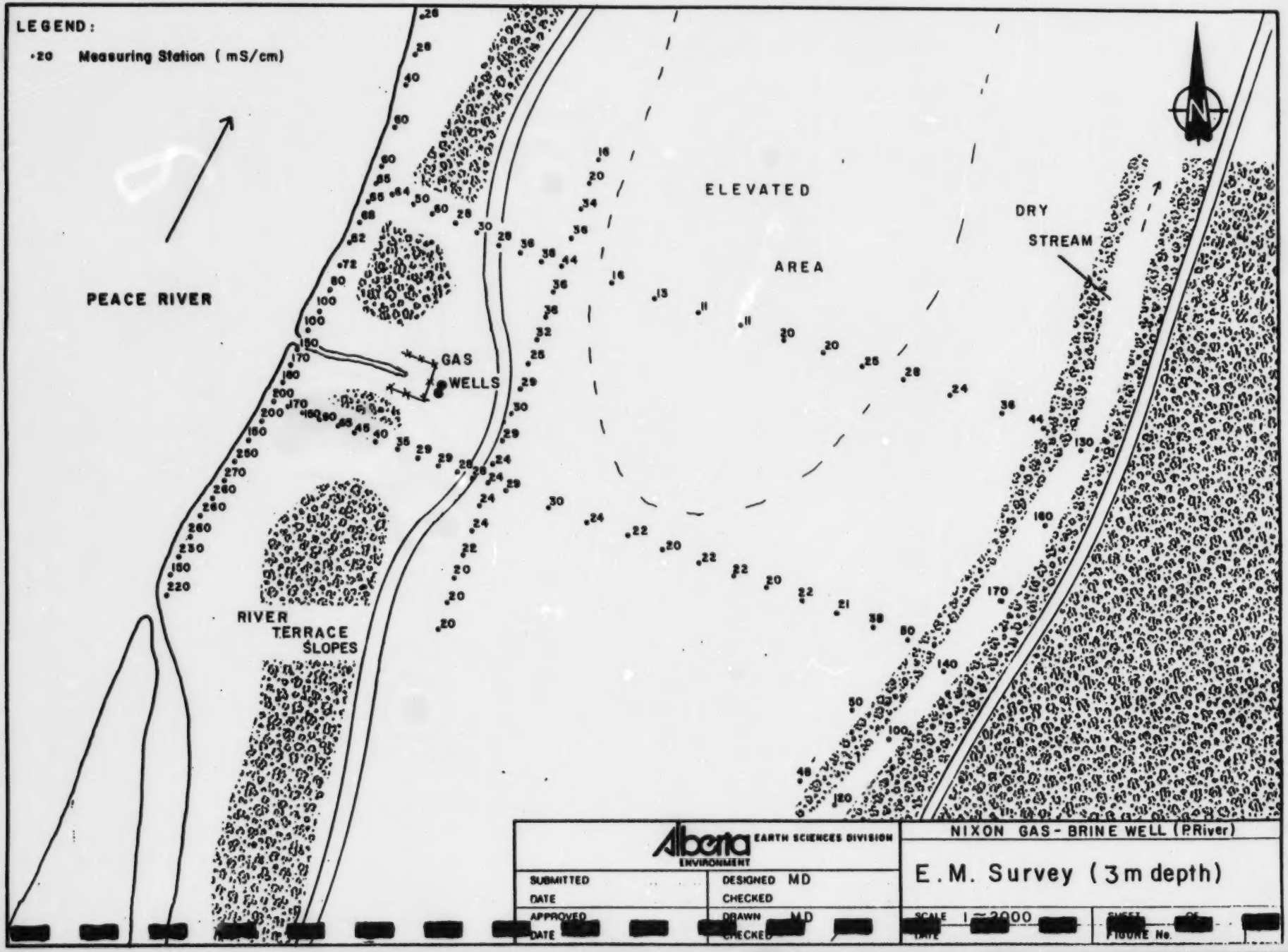
An electro-magnetic (EM) survey was run around the oil well to include a line along the Peace River, and a traverse across a flood-plain and along a flood water channel at the base of the east valley slope where a blow-out cavity was located. This survey also included a line that traversed a collapse feature, thought to be a 'sinkhole'. EM measurements did not decisively reflect elevated ionization in soil and groundwater that would suggest intrusion of saltwater. However, a section of the flood water channel immediately downstream from the blow-out suggests remnant saltwater. Similary, elevated measurements along the river and upstream from the discharge point of the oil well water indicate minor shallow infiltration and flow-through although small springs along the bank contain fresh water only. It is also noted that no EM anomaly exists at the site of subsidence possibly a local structural failure of the subsoil. Early aerial photos indicate the presence of such features along a depositional boundary.

Oil and saltwater seepage has long been observed in the Peace River valley. Natural contamenation is therefore expected in valley soils and groundwater in variable quantities.

Based on the evidence collected the subject well cannot be regarded as cause for the actual or alleged anomalies.



Alberta ENVIRONMENT EARTH SCIENCES DIVISION		NIXON GAS - BRINE WELL (PRiver)
SUBMITTED DATE	DESIGNED MD CHECKED	E. M. Survey (6m depth)
APPROVED DATE	DRAWN MD CHECKED	SCALE 1 ≈ 2000 SHEET OF DATE FIGURE No.


LEGEND:
·20 Measuring Station (mS/cm)
PEACE RIVER
ELEVATED
AREA
DRY
STREAM
GAS
WELLS
RIVER
TERRACE
SLOPES
N
Alberta ENVIRONMENT EARTH SCIENCES DIVISION
SUBMITTED
DATE
APPROVED
DATE
DESIGNED MD
CHECKED
DRAWN MD
CHECKED
NIXON GAS - BRINE WELL (PRiver)
E.M. Survey (3m depth)
SCALE 1:2000
DATE
SHEET OF
FIGURE No.

APPENDIX 9

Routine Water Analysis of
Nixon's Old Domestic Well

Alberta

ENVIRONMENT

MEMORANDUM

WASTES & CHEMICALS DIVISION

FROM Mario deBrentani
Technologist
Groundwater Protection Branch

TO B. Kemper
Head
Env. Quality Monitoring Branch

JBK ⇒ D. Fraser
Sept. 29/89.

OUR FILE REFERENCE SW 4-31-85-20-W5

YOUR FILE REFERENCE

DATE 1989 09 27

TELEPHONE

SUBJECT **Flowing Gas Well at Nixon's Property Near Peace River**

The domestic water well at the Nixon farm was sampled on July 25, 1989.

The well has a 4 inch diameter steel surface casing and is reported to be about 20 m deep. At the time of sampling, the well was blocked at approximately 2 m from the surface with, what appeared to be, wooden debris. A small diameter plastic hose was forced past the obstructions and a water sample was obtained from approximately 4 m down.

The chemical analysis of this sample reflects the quality of the water in the well but not necessarily that of the geological formation in which the well is completed.

To get a representative sample, the well would have to be cleaned out and pumped for a short period of time to remove the stagnant water.

The water analysis of the sample (attached) was done by Alberta Environmental Centre in Vegreville. The water is the sodium bicarbonate type, often associated with bedrock aquifers. Water well records of the area reveal similar water from wells completed in the river valley both upstream (SW 2-85-21-W5) and downstream (SW 16-86-20-W5) of Nixon's farm. Water from wells to the southeast, outside the river valley, is the calcium magnesium sulphate type, commonly associated with drift aquifers.

The chloride level in the Nixon well is, with 156 mg/L (drinking water limit 250 mg/L), the highest of the 11 wells surveyed. Next highest, with 65 mg/L, is a well 5 km downstream, also in the valley.

This high chloride level together with the presence of phenols, suggest that water from the domestic well at Nixon's farm may be contaminated.

Mario deBrentani

MD/dr

Alberta
ENVIRONMENTAL CENTRE
BAG 4000 VEGREVILLE, ALBERTA T0B 4L0
(403) 632-6761

WATER ANALYSIS LABORATORY

CERTIFICATION OF ANALYTICAL RESULTS

FRIDAY AUGUST 18th, 1989

SAMPLE
8907901

SOURCE
PEACE RIVER 427-6182
NIXON'S FARM TIME 3 PM

TYPE AND DESCRIPTION
GROUNDWATER

RESULTS TO
DE BRENTANI, MARIO
GROUNDWATER PROTECTION
10405 JASPER AVE
EDMONTON, AB

WELL DEPTH

SAMPLED BY
DE BRENTANI, MARIO

DATE SAMPLED
25/07/89

DATE RECEIVED
01/08/89

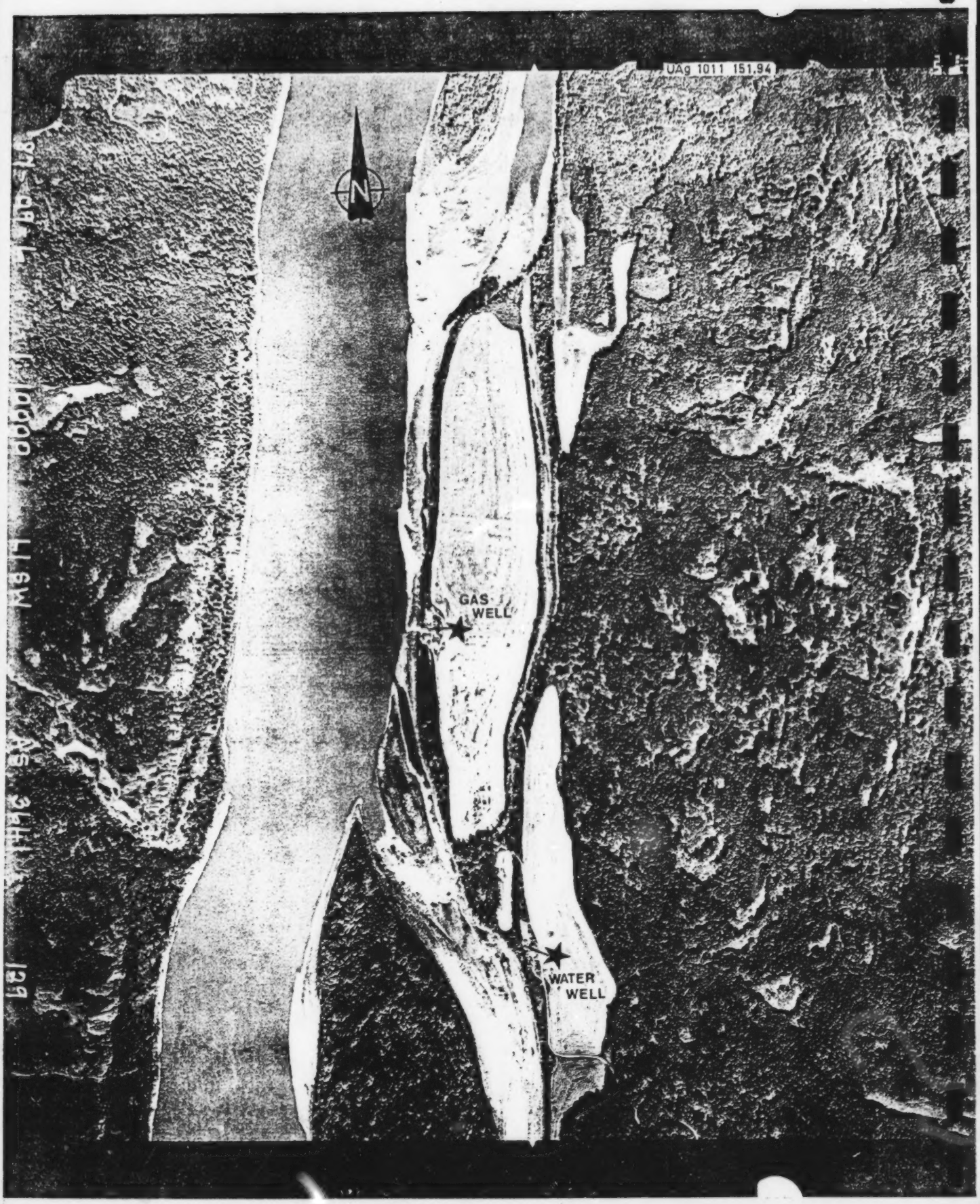
PARAMETER	NAQUADAT CODE	ANALYTICAL RESULTS	UNITS
PH	10301L	7.91	
CONDUCTIVITY	02041L	2320.	uS/cm
TDS(CALCULATED)	00205L	1457.	mg/L
CALCIUM	20107L	55.0	mg/L
MAGNESIUM	12105L	36.0	mg/L
T-HARDNESS	10602L	286.	mgCaCO3/L
SODIUM	11103L	455.0	mg/L
POTASSIUM	19103L	4.3	mg/L
(NO2+NO3)-N	07105L	0.030	mg/L
NO2-N	07205L	0.002	mg/L
FLUORIDE	09107L	0.28	mg/L
SULFATE	16306L	243.	mg/L
CHLORIDE	17206L	156.0	mg/L
SILICA	14107L	16.5	mg/L
T-ALKALINITY	10101L	847.	mgCaCO3/L
BICARBONATE	06201L	1032.	mg/L
CADMIUM	48009L	0.003	mg/L
COPPER	29009L	0.012	mg/L
NICKEL	28009L	0.007	mg/L
COBALT	27009L	0.003	mg/L
ZINC	30009L	0.111	mg/L
BERYLLIUM	04103L	<0.001	mg/L
MANGANESE	25003L	0.254	mg/L
CHROMIUM	24009L	0.005	mg/L
VANADIUM	23009L	0.007	mg/L
MOLYBDENUM	42009L	0.003	mg/L
BARIUM	56009L	0.318	mg/L
IRON (ICP)	26009L	7.330	mg/L
LEAD	82302L	<0.002	mg/L

PARAMETER	NAQUADAT CODE	ANALYTICAL RESULTS	UNITS
COD	08304L	42.	mg/L
PHENOLS	06537L	0.006	mg/L
DOC	06107L	8.0	mg/L
DIC	06154L	206.0	mg/L
CARBON PART	06905L	NO VALUE	mg/L
NITROGEN PART	07906L	NO VALUE	mg/L
CATIONS	00120E	25.60	
ANIONS	00125E	26.40	
BALANCE		0.97	

NO_2 = NITRITE NO_3 = NITRATE
TDS = TOTAL DISSOLVED SOLIDS

COMMENTS
DEPTH: 10M
INTERIM REPORT (PC&PN TO FOLLOW)

CERTIFIED BY AW
FOR DR. F. P. DIEKEN
HEAD, WATER ANALYSIS & RESEARCH BRANCH
CHEMISTRY DIVISION EXT. 255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N
GAS WELL
WATER WELL

APPENDIX 10

Appraisal of Soil and Crop Condition in the Vicinity of the Peace River Oils #1 Well

Alberta ENVIRONMENT

MEMORANDUM

LAND CONSERVATION AND RECLAMATION COUNCIL

FROM: A. Janz
Soils Specialist

OUR FILE REFERENCE:

YOUR FILE REFERENCE:

TO: D. Trew, Head
Environment Quality Monitoring
Branch

DATE: October 6, 1989

TELEPHONE: 427-6212

SUBJECT: Peace River Oils
No. 1 Well 4-31-85-20-W5M
Soils Report

As requested, we submit the final report and map outlining our findings from the site visit on July 25, 1989.

Investigation Date: July 25, 1989
Investigator: Al Malcolm
(Peace River Reclamation Officer)
Arnold Janz (Soils Specialist)

Investigation Methods:

1. Soil profile examination.
2. Apparent conductivity readings (EM-38).
3. General crop appearance.
4. Soil sample collection for lab analysis.

Results:

Lease Site	Approximate Area	Crop Type	Crop Condition
Area A	20 m x 40 m	Wheat	Poor
Area B	20 m x 20 m	Barley	Very Poor
Area C	5 m x 5 m	Barley	Bare
Area D	5 m x 15 m	Barley	Excellent
Area E	30 m x 80 m	Weeds	N/A
Area F	Control	Wheat /Barely	Poor to Excellent

.../2

Table One (attached) outlines some physical and chemical soil properties of areas A through F.

Conclusion:

Area A: Crop growth is reduced due to sour smelling gas within the topsoil and subsoil and very poor surface tilth.

Area B: Crop growth is reduced due to sour smelling gas within the topsoil and subsoil, high Cl levels in topsoil and poor soil structure.

Area C: Crop growth is non existent due to factors including
a) high EC
b) high SAR, and
c) high Cl levels

Area D: Crop growth in area D is excellent because of surplus topsoil, good moisture conditions and no chemical restrictions.

Area E: Fenced area.

Area F: Control area with poor to excellent crop growth.

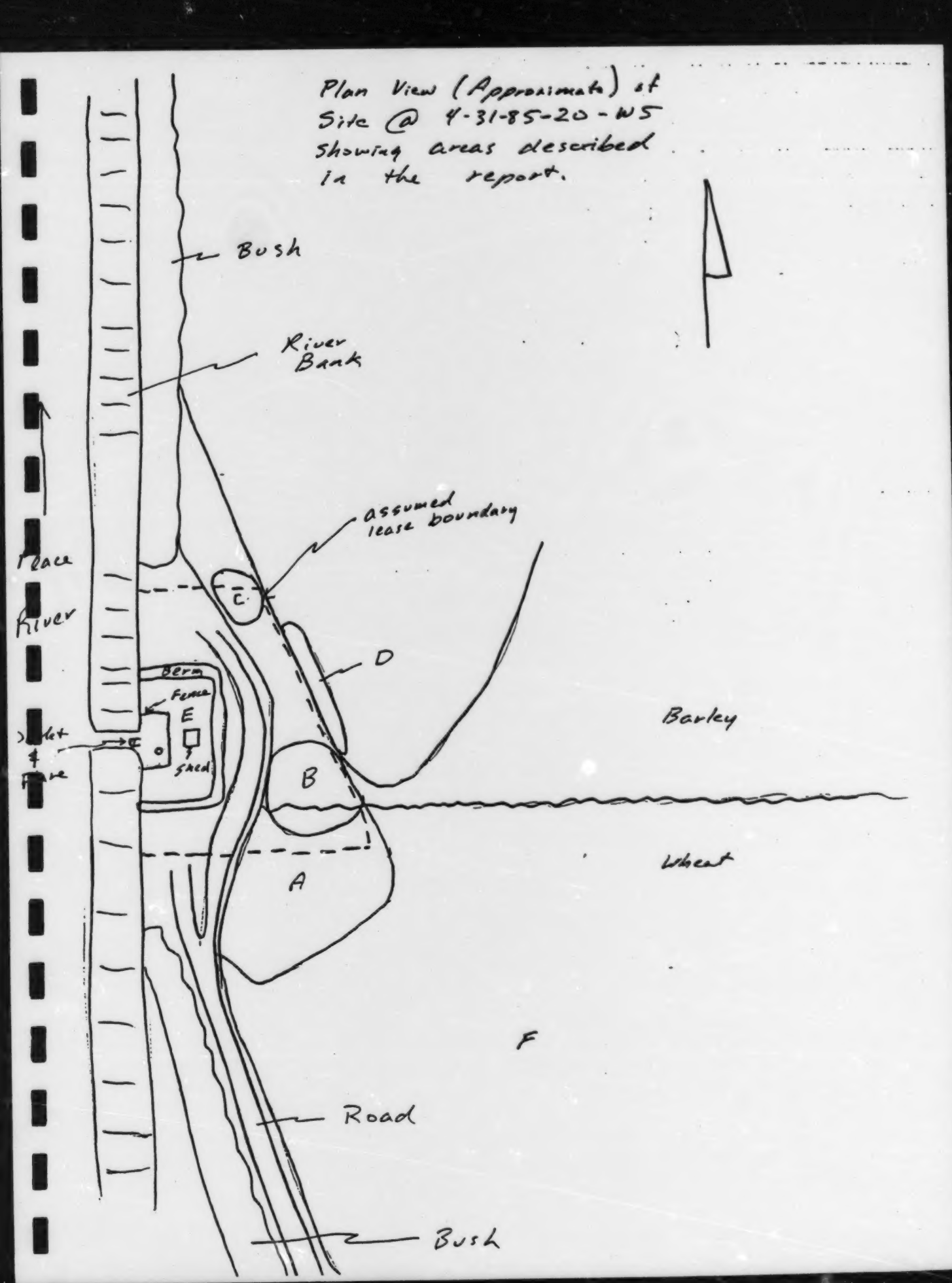
A. Janz

/eh

cc: S. Tracy
J.M. King
A. Malcolm

TABLE ONE

Property (0-15 cm)	Area A	Area B	Area C	Area D	Area E	Area F
Cl (meq/l)	1.14	53.0	73.1	-	-	0.36
pH	7.2	6.9	7.4	-	-	7.7
E.C.	1.52	3.25	14.9	-	-	0.88
SAR	0.2	2.6	15.5	-	-	0.2
Sat %	50	64	51	-	-	56
Om %	4.56	7.90	4.08	-	-	6.21
Texture	L	L	L	SL	SL	L
Moisture	moist	moist	moist	dry	-	dry
Color	red	red	normal	normal	-	normal
Gas	present	present	normal	normal	-	normal
Topsoil depth (cm)	10-15	10-15	15	20	0	15-20
Structure	crusted surface	crusted surface	normal	normal	compact	normal
Hydrocarbon %	0.1	0.11	0.03	0.1	-	-


Plan View (Approximate) of Site @ 4-31-85-20-W5 Showing areas described in the report.
Bush
River Bank
assumed lease boundary
Peace River
C
D
Berm
Fence
E
Shed
Barley
B
Wheat
A
F
Road
Bush